KONINKLIJKE AKADEMIE VAN WETENSCHAPPEN
TE AMSTERDAM.

PROCEEDINGS OF THE MEETING

**of Friday April 27, 1906.**

(Translated from: Verslag van de gewone vergadering der Wis- en Natuurkundige Afdeeling van Zaterdag 31 Maart 1906, Dl. XIV).

CONTENTS.

L. Bolk: "On the relation between the teeth-formulas of the platyrrhine and catarrhine Primates", p. 781.

F. M. Jaeger: "A simple geometrical deduction of the relations existing between known and unknown quantities, mentioned in the method of Voigt for determining the conductibility of heat in crystals". (Communicated by Prof. P. Zeeman), p. 793.

W. Burck: "On plants which in the natural state have the character of eversporting varieties in the sense of the mutation theory". (Communicated by Prof. J. W. Moll). p. 798.

H. Strahl: "The uterus of Erinaceus europaeus L. after parturition". (Communicated by Prof. A. A. W. Hubrecht), p. 812.

P. Zeeman: "Magnetic resolution of spectral lines and magnetic force", (1st part) p. 814. (With one plate).

Jan de Vries: "Some properties of pencils of algebraic curves", p. 817.

H. Zwaardemaker: "On the strength of the reflex-stimuli as weak as possible", p. 821.

**Anatomy.** — *"On the relation between the teeth-formulas of the platyrrhine and catarrhine Primates".* (Communicated by Prof. L. Bolk).

(Communicated in the meeting of March 31, 1906).

Among the anatomical characteristics by which the Primates of the New-World — the platyrrhine apes — are distinguished from those of the Old-World — the catarrhine apes and man — the composition of the set of teeth takes a first place. They are characterized because they possess in the upper and lower jaw one milk-molar with premolar, which replaces this, more than the latter.

In simplified writing the set of teeth of catarrhine Primates may be rendered by the following formula:

$$\begin{array}{l} 2\ I.\ 1\ C.\ 2\ P. \\ 2\ i.\ 1\ c.\ 2\ m.\ 3\ M. \\ \hline 2\ i.\ 1\ c.\ 2\ m.\ 3\ M. \\ 2\ I.\ 1\ C.\ 2\ P. \end{array}$$

in which the teeth of the permanent set of teeth are written with a capital letter.

For the majority of the platyrrhine Primates the following formula holds true:

$$\begin{array}{l} 2\ I.\ 1\ C.\ 3\ P. \\ 2\ i.\ 1\ c.\ 3\ m.\ 3\ M. \\ \hline 2\ i.\ 1\ c.\ 3\ m.\ 3\ M. \\ 2\ I.\ 1\ C.\ 3\ P. \end{array}$$

This last formula is only applicable to the family of Cebidae, whereas the Hapalidae differ from them because they have a molar less, so that the formula for their set of teeth becomes as follows:

$$\begin{array}{l} 2\ I.\ 1\ C.\ 3\ P. \\ 2\ i.\ 1\ c.\ 3\ m.\ 2\ M. \\ \hline 2\ i.\ 1\ c.\ 3\ m.\ 2\ M. \\ 2\ I.\ 1\ C.\ 3\ P. \end{array}$$

The difference however in the set of teeth between Cebidae and Hapalidae is for the present of less importance, the significance of it will be shown later on. In the first place the attention should be fixed on the principal difference between all platyrrhine Primates on one side and all catarrhine ones on the other, i.e. the occurrence of only two milkmolars and premolars with these and of three milkmolars and premolars with those.

It is not doubtful that the set of teeth of catarrhine apes and of man must be deduced from one that was composed like the set of teeth of the now living Platyrrhines with three molars, so compared with the set of teeth of those, the set of teeth of the catarrhine Primates may be considered as reduced, the total number of teeth is larger with the former than with the lâtter. In what way has this reduction of the set of teeth come about, this is a question which has been frequently put and which has been answered in different ways. An obvious conception is certainly this, that a milkmolar with his replacing tooth, the premolar, has become lost. But which of the row has disappeared? This question has been answered in different ways. Whereas the Anthropologists in general are more of the opinion that the last milkmolar and premolar have been linked out, zoologists, palaeontologists and anatomists accept the view

that it has been the first, so that which follows immediately on the caninetooth. The two opinions have in common that they link out a milk molar and its replacing tooth from the continuity of the tooth row. On account of this the two theories may be distinguished as the excalation theories. I cannot agree with any of these opinions, it appears to me that the reduction has been brought about in another way, but this can only be explained more fully, when I shall have brought forward what pleads for and what against each of the above mentioned theories.

The Anthropologists look for their proof material, or perhaps more exactly for the arguing of their theses in the variations in the set of teeth, which occur with man. Of late DUCKWORTH among others has again drawn attention to the fact that rudiments of a tooth, more or less developed often appear between the last bicuspid tooth and the first molar tooth especially in the upper jaw and what is especially of importance, often on both sides. These rudiments are conical tooth-points, now occurring single either on the inner or the outer border of the alveolar margin, then again double on each of the two borders simultaneously. And DUCKWORTH does not hesitate to consider these rudiments as the again visible traces of the linked out third premolar: "on the whole we think that it is most reasonable to adopt the view that they are aborted third premolars, which constitute a human type of dentition similar to that of the New World Apes" [1]). From the investigation of DUCKWORTH the following must be mentioned. Firstly that the occurrence of these rudiments of a third premolar is exceedingly different with the different races: in 300 old Egyptian skulls he found no single case, on the other hand in some thirty skulls of Australians he found these rudiments seven times. The set of teeth of the natives of New-Britain shows this anomaly exceedingly often. With respect to the set of teeth of the Anthropoids, DUCKWORTH mentions that with seven of the thirteen skulls of gorillas, which he investigated, the rudiments in question were present whereas on the other hand he found them not a single time with Hylobates nor with Orang-outans or Chimpanzees.

The reasoning of those who think that the first milkmolar and premolar, following on the canine tooth have fallen out, in the passing from the platyrrhine form to the catarrhine form is of quite a different nature. It is a fact which is generally acknowledged as being true that originally the number of premolars of the primitive Primates did not amount to three but to four; so that already the

---

1) W. H. L. DUCKWORTH. Studies in Anthropology. Cambridge 1904. p. 22.

platyrrhines also, with their three premolars and milkmolars, possess a reduced set of teeth, and indeed among the group, of the primitive Primates which OSBORN puts together under the general name of + Mesodonta, forms are found with which both in upper and lower jaw still four premolars occur (+ Hyopsodus). According to the investigations of LECHE the number of four premolars has decreased to three, because the premolar which follows immediately behind the canine tooth — so the first or front of the row — has become lost. As most convincing for this opinion of LECHE the set of + Microchoerus may count, where only three premolars occur in the upper jaw, and still as many as four in the lower jaw, but of these the first of the row has been reduced to a rudiment without function. Where it is as good as proved that the reduction of four to three premolars with the primitive Primates has been brought about by the disappearance of the premolar following immediately behind the canine tooth, where moreover we know that with other animals also reduction of teeth may take place in this spot, there it is quite comprehensible that the further reduction of four to three premolars in the same place is localized. The difference between the two explained opinions is easily made recognizable by writing down the complete tooth formula of the primitive Primates and that of the now living ones.

For the primitive Primates we get the following formula in which the probably original number of *Incisivi* has not been reckoned with:

*I.* 1. 2. *C.* 1. *P.* 1. 2. 3. 4.
*i.* 1. 2. *c.* 1. *m.* 1. 2. 3. 4. *M.* 1. 2. 3.

---

*i.* 1. 2. *c.* 1. *m.* 1. 2. 3. 4. *M.* 1. 2. 3.
*I.* 1. 2. *C.* 1. *P.* 1. 2. 3. 4.

For the Platyrrhines (Cebidae) the formula becomes:

*I.* 1. 2. *C.* 1. *P.* 0. 2. 3. 4.
*i.* 1. 2. *C.* 1. *m.* 0. 2. 3. 4. *M.* 1. 2. 3.

---

*i.* 1. 2. *c.* 1. *m.* 0. 2. 3. 4. *M.* 1. 2. 3.
*I.* 1. 2. *C.* 1. *P.* 0. 2. 3. 4.

According to the opinion of Anthropologists this formula becomes for the catarrhine Primates:

*I.* 1. 2. *C.* 1. *P.* 0. 2. 3. 0.
*i.* 1. 2. *c.* 1. *m.* 0. 2. 3. 0. *M.* 1. 2. 3.

---

*i.* 1. 2. *c.* 1. *m.* 0. 2. 3. 0. *M.* 1. 2. 3.
*I.* 1. 2 *C.* 1. *P.* 0. 2. 3. 0.

so the milkmolars and premolars of man should be the original 2nd and 3rd.

According to the theory, mentioned in the second place, the formula becomes:

*I.* 1. 2. *C.* 1. *P.* 0. 0. 3. 4.
*i.* 1. 2. *c.* 1. *m.* 0. 0. 3. 4. *M.* 1. 2. 3.

*i.* 1. 2. *c.* 1. *m.* 0. 0. 3. 4. *M.* 1. 2. 3.
*I.* 1. 2. *C.* 1. *P.* 0. 0. 3. 4.

so that with man the original 3rd and 4th milkmolar and premolar would still exist.

The last mentioned opinion seemed to me also to be the most acceptable. It pleads for it, that in a phylogenetically older stadium the first milkmolar and its premolar had already become lost, and if then one lets the second follow, the reduction-process is localized and more continuity brought into it. The following can moreover be said against the opinion of the Anthropologists, that the fourth milkmolar and premolar with man should have been lost. It may be justly supposed that only those teeth can reduce, which fulfill the smallest function. And this now does not apply to the last milkmolar and premolar. On the contrary. With the Platyrrhines we see, that just that last molar does not only not stay behind by the others, but is even the strongest developed of the three. So with those forms, where we might with some right suppose at least some indication to a reduction of this tooth, we on the contrary find a progressive development. No single reason can be given why in the middle of this toothrow a tooth should suddenly have disappeared, and why a discontinuity of the set of teeth should have come about by which the function would have suffered considerably, no single indication can be found, neither in the ontogenetic nor in the full-grown set of teeth, in the form of a diastem, that a tooth has really become lost here, and so the first mode of explanation: that the last milkmolar and its replacing tooth would have become lost, does not seem probable to me.

But neither can the theory that at the passing from the platyrrhine to the catarrhine type, the first milkmolar with the premolar belonging to it, should have been linked out, satisfy me. The above mentioned argument about it, is always only an argument per analogiam without its being possible that a morphological proof for such a reduction can be given. If the sets of teeth of Platyrrhines are compared in particular with relation to the degree of development of the first premolar nothing is found that points to a reduction of this

tooth, at least with the now living forms; on the contrary, the first premolar is often stronger than the second (Cebus, Chrysothrix, Mycetes, Hapale). Then not a single indication can be observed in the Ontogenese of the set of teeth of man, which indicates that a tooth should have become lost behind the canine tooth, the papillae succeed each other very regularly in their origin and place. Moreover if it were right that a molar and a premolar became lost behind the canine tooth the remarkable fact remains still unexplained, that a rudimentary tooth appears so often between the first molar and the last premolar.

So I cannot agree with either of the two opinions which prevail now about the differentiation of the set of teeth of the Primates, but I am of the opinion that it came about in quite another way. To be short, my opinion about it is as follows: the set of teeth of the catarrhine Primates has originated from that of the platyrrhines by the disappearance of the last or third molar and of the last or third premolar while the third milkmolar has lost its character of temporary tooth and has become a permanent tooth.

This opinion is explained by the two following formulas. If we overlook the original number of four milkmolars and premolars, and number the elements of the platyrrhine set of teeth according to their now present amount this set of teeth may be written according to the following formula:

$$\begin{array}{l} I_1.\ I_2.\ C.\ P_1.\ P_2.\ P_3. \\ i_1.\ i_2.\ c.\ m_1.\ m_2.\ m_3.\ M_1.\ M_2.\ M_3. \\ \hline i_1.\ i_2.\ c.\ m_1.\ m_2.\ m_3.\ M_1.\ M_2.\ M_3. \\ I_1.\ I_2.\ C.\ P_1.\ P_2.\ P_3. \end{array}$$

The catarrhine set of teeth has originated from this, as $P_3$ and $M_3$ have fallen away in the upper and lower jaw, whereas $m_3$ becomes $M_1$ in both jaws, by which as a matter of course $M_1$ of the platyrrhines becomes $M_2$ of the catarrhines, the $M_2$ of the former becomes $M_3$ of the latter. If it had remained the $M_3$ of the platyrrhines would have become $M_4$ of the catarrhines. Those things are stated in the following formula in which the reduced teeth are put between parenthesis.

$$\begin{array}{l} I_1.\ I_2.\ C.\ P_1.\ P_2.\ [P_3]. \\ i_1.\ i_2.\ c.\ m_1.\ m_2.\ M_1.\ M_2.\ M_3\ [M_4]. \\ \hline i_1.\ i_2.\ c.\ m_1.\ m_2.\ M_1.\ M_2.\ M_3.\ [M_4]. \\ I_1\ I_2.\ C.\ P_1.\ P_2.\ [P_3]. \end{array}$$

So the differentiation of the set of teeth of the Primates is accord-

ing to my view more complicated than would have been the case according to the two above mentioned excalation theories. Two phenomena may be distinguished in this process of development, namely progressive development of one of the elements: $m_3$ loses its character of temporary element and becomes persistent, and the second phenomenon is the reduction of two other elements. These two elements are at the extremity of each of the two tooth series, $P_3$ at the end of the series of replacing teeth, $M_3$ of the end of the series of the teeth of the first generation. Contrary to the two above mentioned excalation hypotheses I might distinguish the one defended by me as the hypothesis of the terminal reduction. I shall try to show the correctness of my opinion.

If I let $m_3$ of the Platyrrhines become a persistent tooth, no new principle is introduced into odontologie. For it is kwown to us from other groups of animals that milk teeth may become persistent teeth; I remind the reader of the Marsupialia, where but for some exceptions the whole set of milk teeth has become a set of persistent teeth except a single tooth. Furthermore to Erinacaeus, where according to the investigations of LECHE the so called persistent set of teeth consists partly of milk teeth partly of permanent teeth. So my opinion is nothing more than a new example of the tendency also observed elsewhere of a diphyodont set of teeth to pass into a monophyodont. So against the principle as such there can be no objection.

As a first argument for the correctness of my opinion I state the morphology of the milk molars in platyrrhines, I had the opportunity of studying them from Hapale, Chrysothrix, Cebus, Mycetes, Pithecia and Ateles. Without going into details it must only be mentioned here that $m_3$ of the platyrrhines differs a great deal both in the composition of its crown and in the number of its fangs from $m_1$ or $m_2$ and shows much resemblance to $M_1$ of these apes.

It is of much importance with this that $m_3$ is functionally a higher developed tooth than its deciduous tooth $P_3$, so that means that at the moment that $m_3$ is replaced by $P_3$, the set of teeth becomes to a certain degree functionally inferior. So if $m_3$ becomes persistent, this means a gain for the mechanism of the set of teeth. This does not hold true for $m_1$ and $m_2$, the replacing $P_1$ and $P_2$ are functionally higher developed.

A second motive is derived from the development of the set of teeth of the catarrhine Primates, in particular that of man. So according to my opinion our first molar has passed from a milk tooth into a persistent tooth in a relatively recent stadium, with the Platyr-

rhines it still belongs to the milk teeth. May this not be the explanation of the fact that our first molar still breaks through in connection with the teeth of the set of milk teeth, and still before the appearance of the first replacing tooth, while the second tooth appears only after a period of some years? By this early appearance of our first molar it functionates indeed for some time together with the complete set of milk teeth and so according to my opinion the set of teeth of man still possesses in this period a composition as in the first lifetime of the Platyrrhines. Still more distinctly than from the time of the eruption this relation appears when the first forming during the ontogonese is more closely investigated. I derive the following about this from the wellknown investigation of Röse [1]). Between the 9th and 12th week of the faetal development the papillae of the milk teeth are invaginated in the dental band (Zahnleiste) which grows on uninterruptedly towards the back, and already in the 17th week of the development the papilla of the first molar is invaginated. So with man there is not the least histogenetical discontinuity between the forming of the milk teeth and of the first molar. Only after the course of a year, sc four months after the birth the dental band begins to grow on towards the back and not before the 6th month after birth the papilla of the second tooth is invaginated. So while $M_1$ is formed immediately after $m_2$ with man, a pause of about a year begins after this first development. So both from morphology and ontogeny arguments may be derived for the hypothesis that $m_3$ of the Platyrrhines is homological to $M_1$ of the Catarrhines.

My hypothesis however still contains another element viz. the reduction of $P_3$ and $M_3$ of the Platyrrhines.

Let us first consider the reduction of $M_3$. From my above mentioned deduction of the catarrhine set of teeth given in a formula, follows that I come in conflict with a rather generally accepted opinion that the three molars of the Catarrhines should be homologue to the three molars of the Platyrrhines. According to my opinion $M_1$ of the Platyrrhines is homologue to $M_2$ of the Catarrhines, $M_2$ of those homologue to $M_3$ of these, and in the set of teeth of the Catarrhines the homologon of $M_3$ of the Platyrrhines is wanting. If this tooth should also appear by the last mentioned group of Primates it would become a $M_4$. Now it is a fact that is universally known that a more or less developed fourth molar is not seldom with man and among the Anthropoids, especially

[1]) G. Röse, Ueber die Entwicklung der Zähne des Menschen. Arch. f. mikrosk. Anat. Bnd. XXXVIII.

with the Orang and Gorilla. Moreover ZUCKERKANDL [1]) has shown that the epithelial rudiment of a fourth molar of man is formed with the majority of the individuals. This rudiment of a tooth and the eventual eruption of the fourth molar were till now phenomena which were somewhat difficult to interprete. There was an inclination to keep this fourth molar with man for an atavism and the set of teeth of man was deduced from a hypothetical primitive form when the set of teeth contained four molars. Here however the difficulty offers itself that among the already numerous well known primitive Primates there has never been found a form with four molars. ZUCKERKANDL also reveals this difficulty where he points to it that four molars should only appear with the primitive forms of the carnivores. SELENKA [2]) also, who found from his rich material that with Orang in 20% of the cases appears a fourth molar feels the mentioned difficulty and interprets the variation in another way. It should not be atavism but a progressive phenomenon in that sense, that the set of teeth of Orang is on the way of bringing into development a fourth molar. It appears to me that this explanation of SELENKA is not correct. If this variation were only known to us from Orang, no direct difficulties could be stated against this hypothesis. But such a fourth molar also occurs as I said before very often with man. And now it is not doubtful that the extremity of the human set of teeth is in a state of regression, the third molar is always more or less reduced and even according to the investigations of DE TERRA [3]) and others issues no more with at least 12% of the recent Europeans. Where it is now fixed that our set of teeth reduces at its extremity, the formation and issue of a fourth molar can hardly be interpreted as a progressive phenomenon.

The hypothesis brought forward by me gives a simple solution of the difficulty. The fourth molar of man and of the Anthropoids is indeed an atavism but does not refer back to a removed primitive form unknown to us, but does not go any farther than to the nearest past of the history of development of our set of teeth, it is the homologon of $M_3$ of the Platyrrhines. And contemplated in such a way the relatively frequent occurrence of it can no longer surprise us.

---

[1]) E. ZUCKERKANDL, Vierter Mahlzahn beim Menschen. Sitzungsber. der k. Akad. d. Wiss. Wien Bnd. C.

[2]) E. SELENKA. Menschenaffen. Rassen, Schädel und Bezahnung des Orang Utan. Wiesbaden 1898.

[3]) M. DE TERRA. Beiträge zu einer Odontographie der Menschenrassen. Zürich 1905.

More direct proofs may however be cited for the conclusion that $M_3$ of the Platyrrhines should be reduced. For if the sets of teeth of different representatives of this group are investigated, it is undeniable that $M_3$ is behind in development to $M_2$ and $M_1$.

Not all Platyrrhines are alike in this regard, with some species the set of teeth is apparently very constant with other it is more variable. A particularly fixed set of teeth Chrysothrix seems to possess. I could at least find not a single deviation in the 130 skulls of Chrysothrix sciurea which I possess, no more in 60 skulls of Cebus fatuellus, although the $M_3$ is already very much reduced with this species. Ateles on the contrary seems to possess a set of teeth which is richer in variations and BATESON [1]) mentions three cases in which the $M_3$ which is already reduced in this genus quite fails. The mentioned author points to it that in these cases Ateles possessed a formula for its set of teeth which is typical for the second family of the Platyrrhines — the Hapalidae. And in connection with this I may now examine the set of teeth of the Hapalidae in the light of my hypothesis. This hypothesis puts that $M_3$ of the Platyrrhines became lost in passing to the catarrhine type, that $m_3$ becomes $M_1$ and that $P_3$ no longer issues. Where a reduction of $M_3$ is not seldom found with the Cebidae, and now and then even it is quite wanting as an individual variation, there $M^3$ is already constantly absent with the Hapalidae. So with these Platyrrhines one phase of the process has already been run through, but not yet the second phase, the progression from $m_3$ to $M_1$. So according to my opinion the set of the Hapalidae does not stand as a deviating form at the side of that of the other Platyrrhines, but must be considered as an intermediate form, between the original platyrrhine and the definite catarrhine set of teeth.

So we see that several phenomena plead for my opinion, that the catarrhine set of teeth has not originated by an excalation but by a terminal reduction, and I must stop at my assertion that, because $m_3$ has become $M_1$ the replacing tooth, which originally belonged to it, i.e. $P_3$ no longer appears.

By this supposition, the observation of the anthropologists is done justice to, that a rudimentary tooth does relatively often appear with man and Gorilla between $P_2$ and $M_1$. When $P_3$ has only been suppressed as a normal element of the set of teeth, in a relatively recent period of the development, than the supposition lies at hand, that this tooth also like $M_3$ of the Platyrrhines ontogenetically will be formed

---

[1]) W. BATESON. Materials for the Study of Variation. London, 1894.

still. And it is my opinion that the rudiments of a tooth which so often occur in the indicated place are indeed traces of the $P_3$ which has got lost.

There could still be mentioned some more anomalies in the set of teeth of man (the growing together of $M_1$ with a superfluous tooth, the pushing out of $M_1$ and replacing by a new tooth (so called third dentition) which would be explained by my hypothesis, but I will not look more closely into this matter in this place.

By my opinion about the differentation of the set of teeth of the Primates I come into conflict with a rather universally prevailing opinion about the morphological significance of the first molar of the Placentalia. This molar is universally considered with all Placentalia as a perfectly homological element of the set of teeth. Thus says SCHLOSSER [1]) e. g. speaking of the first molar of man: "Niemand wird sicher die Homologie dieses Zahnes mit dem ersten Molaren der übrigen Placentalier bestreiten dürfen". Where I now homologise $M_1$ of man with $m_3$ of the Platyrrhines I come into conflict with this opinion. If we however try to find motives for the above mentioned opinion in literature, we seek in vain. And so it seems to me, that here we have to do with a dogma, which is not without danger for the comparative anatomy of the set of teeth. For it lies at hand that as soon as in the whole row of the Placentalia one element of the set of teeth is fixed in its morphological significance, that then the homologating of the other elements must join itself to this aprioristical principle. And where such a thing is possible to a certain degree with a canine tooth, which is sharply distinguished from the other teeth by its peculiar form, it is absolutely impossible with a definite molar which possesses no specific morphological qualities.

I cannot finish this communication before having pointed to a phenomenon, which is immediately related to the here communicated point of view. If we compare the set of teeth of man with that of the other catarrhine Primates, it appears that the process, by which the catarrhine set of the teeth orginated from the platyrrhine type, is still progressive with man, and that the human set of teeth is on its way to differentiate from that of the other Catarrhines in the same way, as these differentiated from the Platyrrhines one time. I shall try to show this in short. The still active differentiation of the human set of teeth appears from different facts. First as to the premolars. In comparison to all other Primates the premolars of men

---

1) M. SCHLOSSER. Das Milchgebiss der Säugetiere. Biol. Centralblatt, Bnd. 10, blz. 89.

have been reduced considerably, and the 2nd premolar more than the first. Where as the premolars in the upper jaw of all other Catarrhines possess three and in the lower jaw two fangs, the premolars of man have normaliter one single fang. That this has originated from several, appears from the grooves on the surface. Now it is not without significance that the first premolar shows its origine of a form with several fangs, by a dividing of the point of the fang. So $P_2$ is more reduced than $P_1$ with man. If further the milkmolars, which temporarily precede the premolars are compared, we state that the milkmolars differentiate progressively in the group of the catarrhines, and this is especially the case with the second milkmolar. The progression concerns especially the crown of the teeth, the number of roots is two in the lower jaw, three in the upper jaw.

So if we for a moment fix our attention exclusively on $m_2$ and its replacing tooth $P_2$ with man, it appears that the first is in progression, the second in regression, and that with man, the same relation exists in regard to these two teeth as with $m_3$ and $P_3$ of the Platyrrhines. When man namely pushes out his $m_2$ and replaces it by $P_2$, his set of teeth becomes functionally inferior, for instead of a tooth with five or four knobs on the crown and two or three fangs there comes in its place a tooth with two cusps on the smaller crown and only one root.

So we see, that the terminal element of the dental band of the second generation ($P_2$) reduces with man. Still distinctly may be seen the terminal reduction of the tooth band, of the first generation, closing with $M_3$, for as is already mentioned our $M_3$ no longer even issues in $\pm 12\,\%$ of all cases, and is always behind in development, at least with more highly developed human races. So the human set of teeth is characterized from the catarrhine Primates by the following peculiarities; the last molar is on its way of reduction, the last premolar is on its way of reduction, the last milkmolar has developed very progressively. So a trio of phenomena which are entirely homological to those, by which the catarrhine set of teeth has originated from the platyrrhine. Only one phase is still wanting to the process, namely the remaining persistent of the last milkmolar and the suppression of the last premolar. And this phase also is reached now and then individually. This among others appears from what Magitot says: La persistance des grosses molaires temporaires ($m_2$) s'observe très-souvent, concurremment avec l'absence congénitale ou l'atrophie des secondes prémolaires ($P_2$)

Nous en connaissons de nombreux exemples[1]). If the stated phenomena are connected with each other the conformity to the earlier process of development of the set of teeth of the Primates as I take it, immediately strikes the eye; and one would be inclined to this thesis; In the future set of teeth of man $P_3$ will no longer erupt, $m_3$ will have become persistent and functionate as $M_1$, but by the simultaneous reduction of $M_3$ the number of molars will not have become larger than three.

So from this communication appears that the differentiation of the entire set of teeth of the Primates is from my standpoint more intricate than was supposed till now, but it seems to me that my principle of the terminal reduction can better be brought into accordance with the function of the set of teeth, and is based on a larger number of facts than the hypothesis of the excalation. What from a general point of view, also seems to me to plead for my opinion is the fact, that in the exposition given by me the development of the set of teeth has taken place without a discontinuity in the toothrows at any time.

**Physics.** — "*A simple geometrical deduction of the relations existing between known and unknown quantities, mentioned in the method of* VOIGT *for determining the conductibility of heat in crystals.* By Dr. F. M. JAEGER. (Communicated by Prof. P. ZEEMAN.)

(Communicated in the meeting of March 31, 1906).

It is commonly known that about ten years ago W. VOIGT[2]) indicated a method, based on a recognized principle of KIRCHHOFF, by which to determine the relative conductibility of heat in crystals in the different directions. His mode of experimental examination consists in the determination of the break which two isothermal lines present at the boundary line of an artificial twin, the principal directions of which form a given angle $\varphi$ with that line, whilst the conduction of heat takes place along the line of limit. The isothermal lines are rendered visible to the eye by the tracings formed by the fusion of a mixture of elaidic acid and wax with which the plane of the crystal has previously been covered.

---

[1]) E. MAGITOT. Traité des Anomalies du Système dentaire. Paris 1877. p. 221.

[2]) VOIGT, Göttinger Nachrichten, 1896, Heft 3.

The method of VOIGT is far more accurate than that of DE SÉNARMONT [1]) or even of RÖNTGEN [2]), and, requiring for other purposes to investigate the relative conductibility of heat in crystals, it was obvious that I should make use of the method indicated by VOIGT.

For a crystal, for which the rotatory coefficients, found in accordance with the theory of G. C. STOKES [3]), are $= 0$, VOIGT deducts the relations required here by constructing the equations of the flow of heat, conformable to the conditions of limit which are common to the lateral boundaries of both plates; i.e. that *along* that line the loss of temperature must be the same, and moreover that in a direction normal to that boundary-line the entire flow of heat must be the same in the two contiguous plates.

Prof. LORENTZ had the kindness to derive the above mentioned relations in an analogous manner and to note down the conditions under which the break in the isothermal lines will reach its maximum.

If $\varepsilon$ be the break, and $\phi$ the angle, formed in the plates by the two principal directions, is 45°, the proportion of the two coefficients of the conduction of heat in those directions, consequently $\frac{\lambda_1}{\lambda_2}$ is found as follows:

$$tg\varepsilon = (\lambda_1 - \lambda_2)\frac{(\lambda_1+\lambda_2)}{2\lambda_1\lambda_2}.$$

If $\varphi$ differs from 45°, VOIGT finds in that case:

$$tg\beta = \frac{(\lambda_1-\lambda_2)\sin 2\varphi}{(\lambda_1+\lambda_2)-(\lambda_1-\lambda_2)\cos 2\varphi},$$

which for $\varphi$ equal to 45° passes into the formula of Prof. LORENTZ by introducing $tg\frac{\varepsilon}{2}$ ($= tg\beta$ according to VOIGT's deduction) instead of $tg\varepsilon$.

Instead of the complicated formulae which are required for the determination of these relations, we here give a simple geometrical demonstration, which, besides presenting $\frac{\lambda_1}{\lambda_2}$ in a form which is immediately available for logarithmic calculations, possesses at the same time the advantage of being easily discernible.

If, from a given point $O$ in the centrum of a crystal, a flow of heat can take place without interruption in all directions, the isothermal

---

[1]) DE SÉNARMONT, Compt. rend. **25**, 459, 707. (1847).

[2]) RÖNTGEN, Pogg. Ann. **151**, 603, (1874).

[3]) STOKES, Cambr. and Dublin Math. Journal. **6** 215, (1851).

surfaces in a similar plane of a crystal are, in most cases, concentric and equiform three-axial ellipsoids whose half axes stand in the relation of $\sqrt{\lambda_1}, \sqrt{\lambda_2}$ and $\sqrt{\lambda_2}$; among these the so-called principal ellipsoid $h$, whose axes are $\sqrt{\lambda_1}$, $\sqrt{\lambda_2}$ and $\sqrt{\lambda_3}$ must here be kept more especially in view.

In the present case we leave unnoticed the rotatory qualities of the crystal, and suppose an infinitely thin plate, cut parellel to a plane of thermic symmetry, whose principal directions correspond to the coordinate axes. Let fig. 1 represent the elliptic intersection of the plate with the ellipsoid $h$; the line traced by the melted wax then has the direction of the tangent of the ellipse in the point $P(x'y')$, given by the radius vector $\varrho$, which may enclose the angle $\varphi$ with the axis $X$. The flow of heat may thus proceed along $\varrho$, being the boundary line. In this case the equation for the isothermal line $pq$ is:

$$\frac{xx'}{\lambda_1} + \frac{yy'}{\lambda_2} = 1.$$

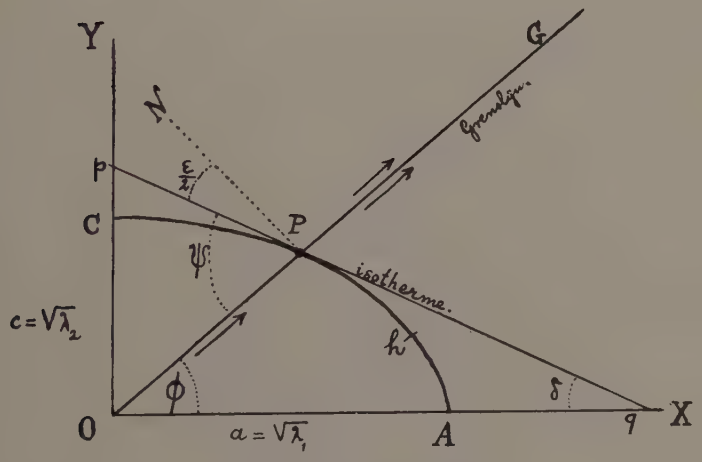


Fig. 1.

Thus for the two sections $Op$ and $Oq$ cut off on the two axes the result is:

$$O_p = \frac{\lambda_2}{y'} = \frac{\lambda_2}{\varrho \sin \varphi}$$

$$O_q = \frac{\lambda_2}{x'} = \frac{\lambda_1}{\varrho \cos \varphi}$$

therefore:

$$\frac{O_p}{O_q} = \frac{\lambda_2}{\lambda_1} \cot \varphi.$$

On the other hand however:

$$\frac{O_p}{O_q} = tg\,\delta = tg\left\{90° - \left(\varphi + \frac{\varepsilon}{2}\right)\right\} = cot\left(\varphi + \frac{\varepsilon}{2}\right),$$

where $\frac{\varepsilon}{2}$ is half of the break of the isothermal lines at the boundary line $OG$.

The immediate conclusion is therefore:

$$\frac{\lambda_1}{\lambda_2} = tg\left(\varphi + \frac{\varepsilon}{2}\right) cot\,\varphi \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (A)$$

From this equation the required proportion may be at once deduced when $\varphi$ represents the direction of the plate and the value of $\varepsilon$ has been ascertained.

Moreover it will be easy to find the maximum of $\varepsilon$ — and thus reduce the errors of investigation to the lowest figures. Suppose $A = \frac{\lambda_1}{\lambda_2}$, the above stated formula, after a few goniometrical transformations becomes:

$$tg\,\frac{\varepsilon}{2} = \frac{(A-1)\,sin\,2\varphi}{(A+1) - (A-1)\,cos\,2\varphi}.$$

This function will be a maximum for $\frac{d\varepsilon}{d\varphi} = 0$, i. e.

$$\frac{d\varepsilon}{d\varphi} = \frac{2\,\{(A^2-1)\,cos\,2\varphi - (A-1)^2\}}{(A^2+1) - (A^2-1)\,cos\,2\varphi} = 0.$$

The maximum condition then becomes:

$$cos\;2\varphi = \frac{A-1}{A+1} = \frac{\lambda_1-\lambda_2}{\lambda_1+\lambda_2},$$

and the appertaining maximum break $\varepsilon$ in the isothermal lines is then expressed by:

$$tg\,\frac{\varepsilon}{2} = \frac{(\lambda_1-\lambda_2)}{2\sqrt{\lambda_1\lambda_2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (B)$$

In cases where the difference between $\sqrt{\lambda_1}$ and $\sqrt{\lambda_2}$ is very small — and observation teaches that this is usually the case — the notation may be:

$$tg\,\frac{\varepsilon}{2} = \frac{\lambda_1-\lambda_2}{\lambda_1+\lambda_2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (C)$$

For practical purposes therefore, the theoretical maximum $\varphi = 45°$ may be taken as fairly accurate, so that then the twin plate with

the isothermal lines etc., takes the form of fig. 2. In that case it follows from $A$:

$$\frac{\lambda_1}{\lambda_2} = tg\left(45° + \frac{\varepsilon}{2}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (D)$$

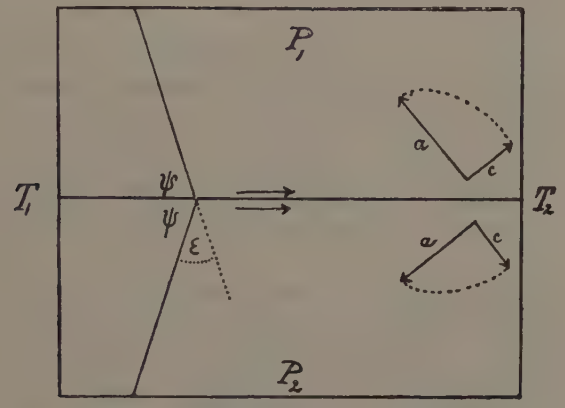


Fig. 2.

By expressing $tg\,\varepsilon$ as a function of $tg\,\frac{\varepsilon}{2}$ from $(C)$ one obtains the relation deduced by Prof. LORENTZ;

$$tg\,\varepsilon = (\lambda_1 - \lambda_2)\,\frac{(\lambda_1 + \lambda_2)}{2\,\lambda_1\,\lambda_2}.$$

Moreover from the geometrical solution here given the fact is again brought to light that in general the angle $\psi$ is not equal to 90°; in other words in this simple but experimental way is proved by occular demonstration the truth of the statement already made by VOIGT, that the isothermal lines in crystals do not generally stand perpendicular to the direction of the flow of heat.

Along the thermic axes however this is the case, because the tangent lines at the ellipses are there directed perpendicularly to these axes.

From fig. 1 also follows the form of the break as a result of $\lambda_1 \gtrless \lambda_2$.

I hope soon to communicate the results obtained in the measurement of crystals by means of this method, together with a few observations on the differences of these results with those, derived in the same minerals by the usual methods of DE SÉNARMONT and RÖNTGEN.

**Botany.** — *"On plants which in the natural state have the character of eversporting varieties in the sense of the mutation theory."* By Dr. W. Burck. (Communicated by Prof. J. W. Moll).

(Communicated in the meeting of March 31, 1906).

An investigation of the causes of Cleistogamy [1]) showed that: 1 plants with closed flowers originated by mutation from plants with chasmogamic flowers and 2 that they occur in the natural state, partly as constant, partly as ever-sporting varieties.

In the course of this investigation the question arose whether other wild-growing plants do not also have the character of ever-sporting varieties.

Especially those plants were thought of that have bisexual and unisexual flowers in one and the same individual or in which by the side of bisexual, unisexual individuals are found and also those plants among the dioecious ones that possess rudimentary stamens or ovaries, from which may be inferred that they originated from plants with bisexual flowers.

The agreement between unisexual, cleistogamic and filled flowers pointed to the same origin, while the resemblance in the manner in which unisexual flowers occur among the hermaphrodite ones and closed flowers among the chasmogamic ones, justified the assumption that in the monoecious and dioecious as well as in the cleistogamic we have ever-sporting and constant varieties.

This summer I tried to confirm this conception in a twofold manner, firstly by cultivating the gyno-monoecious *Satureja hortensis* and secondly by studying the different forms in which one and the same andro-monoecious Umbellifer can occur in nature with regard to the number of male flowers in proportion to that of the bisexual ones and to the place which the male flowers occupy on the principal and secondary axes.

To the results of the culture experiments I shall return afterwards when I shall have had an occasion to repeat these experiments on a larger scale and with more species. I will here only mention that they showed that a gyno-monoecious *Satureja hortensis* begins its period of flowering with producing bisexual flowers only, that not until later, when the plant has grown stronger, a few female flowers appear among the bisexual ones, that their number gradually increases

[1]) Die Mutation als Ursache der Kleistogamie. Recueil des Travaux Botaniques Néerlandais Vol. II. 1905.

in the following days until a definite maximum is reached, after which it gradually decreases again until at the end of its flowering-period the plant again produces bisexual flowers only.

Hence the female flower follows the law of periodicity established by DE VRIES for the occurrence of anomalies of various nature with other plants and it may in this respect be put on a line with such anomalies. It may be compared with the increased number of leaflets of *Trifolium pratense quinquefolium*, with the filled flowers of *Ranunculus bulbosus semiplenus*, with the ramified spikes of *Plantago lanceolata ramosa*, etc.

In what follows I shall give the results obtained with the andro-monoecious Umbelliferae.

The investigations of BEIJERINCK [1]), SCHULZ [2]), KIRCHNER [3]), MAC LEOD [4]), LOEW [5]), WARNSTORF [6]), and others on the sexual relations of the Umbelliferae have shown that by far the most species are andro-monoecious and that besides in some of them forms occur with female or with female and asexual flowers. Male flowers appeared in this family to be as common as bisexual ones. Male individuals are rare, however. Until now *Trinia glauca* was considered the only Umbellifer in Europe, known in the male form. From SCHULZ's notes it appears, however, that in the environs of Halle a. S. also male plants of *Oenanthe fistulosa* [7]) and *Sium latifolium* [8]) occur, while in this country also *Heracleum Sphondylium* can occur in the male form.

Far less general are female flowers. SCHULZ only mentions them for (*Eryngium campestre*)? [9]), *Trinia glauca*, *Pimpinella magna*,

---

[1]) BEIJERINCK, Gynodioecie bei Daucus Carota L. Nederlandsch Kruidkundig Arch. Tweede serie 4e Deel 1885, p. 345.

[2]) AUGUST SCHULZ, Beiträge zur Kenntniss der Bestäubungseinrichtungen und Geschlechtsvertheilung bei den Pflanzen. Bibliotheca botanica. Bd. II 1888, Heft 10 und Bd. III 1890, Heft 17.

[3]) O. KIRCHNER, Flora von Stuttgart und Umgebung 1888.

[4]) J. MAC LEOD, Over de bevruchting der bloemen in het Kempisch gedeelte van Vlaanderen. Botanisch Jaarboek Dodonaea 1893 en 1894.

[5]) E. LOEW, Blütenbiologische Floristik des mittleren und nördlichen Europa sowie Grönlands. 1894.

[6]) C. WARNSTORF Blütenbiologische Beobachtungen aus der Ruppiner Flora im Jahre 1895. Verhandlungen des botanischen Vereins der Provinz Brandenburg Bd. XXXVIII. Berlin 1896.

[7]) SCHULZ, Beitr. I p. 47.

[8]) SCHULZ, Beitr. I p. 48.

[9]) In his note concerning this plant on page 42 of his first paper, female flowers are not mentioned. So this is perhaps an error in the general summary at the end of the second paper.

*P. saxifraga* and *Daucus Carota*, for which latter plant BEIJERINCK had already found them before.

In the long list of 66 European Umbelliferae in the Blütenbiologische Floristik of LOEW no more than 16 species occur that are only known as bisexual plants whereas 40 are andromonoecious. It has appeared since that with three of the plants mentioned as bisexual also male flowers are found. Of *Anethum graveolens*, *Aethusa Cynapium* and *Heracleum Sphondylium* namely, WARNSTORF found andromonoecious forms in the environs of Neu-Ruppin; also in this country they occur in this form. Of the 66 Umbelliferae that were studied, the following remain of which until now no other than bisexual plants are known:

*Laserpitium pruthenicum*, *Peucedanum venetum*, *Crithmum maritimum*, *Silaus pratensis*, *Seseli Hippomarathrum*, *S. annuum*, *Anthriscus vulgaris*, *Bupleurum longifolium*, *falcatum*, *tenuissimum* and *Pleurospermum austriacum*, to which list I think must be added: *Eryngium maritimum*, *Berula angustifolia*, *Conium maculatum* and *Helosciadium nodiflorum*.

It is probable that of some of these plants andro-monoecious forms will be found when they are examined over a larger part of their region of occurrence, especially since it has appeared that the different forms in which Umbelliferae can occur, are often spread over very different and widely distant parts, so that, even though the species mentioned be only known as hermaphrodite plants in a part of Europe, the possibility must be granted that they occur in other forms elsewhere.

Of *Sium latifolium* e. g., no other but the andro-monoecious form is found in a great part of Middle Europe and until now only in the environs of Halle a/S accompanied by the male form, evidently only in a few specimens. Only in our country the bisexual form is known.

Of *Pimpinella magna* the bisexual plant is only found in southern Tyrol and Italy; the andro-monoecious on the other hand in the whole of Middle Europe, while in southern Tyrol and Italy the same plant also occurs with female and with female and asexual flowers.

Of *Oenanthe fistulosa* the andro-monoecious plant is found everywhere, the male one until now only in the environs of Halle.

Of *Aethusa Cynapium* the hermaphrodite plant is known in the whole of Middle Europe, the andro-monoecious one only in the neighbourhood of Neu-Ruppin and of my residence.

Of *Daucus Carota* the andro-monoecious form is generally found,

the bisexual one until now only in Flanders [1]) and in this country [2]).

So it is not at all unlikely that of those species which until now are known as bisexual only, later other forms will also be found, and similarly it may be assumed that of the large number of Umbelliferae of which now only the monoecious form is known, on closer examination also the hermaphrodite or unisexual forms will be found.

Meanwhile it is a very remarkable fact that by far the most Umbelliferae are andro-monoecious and that exactly these forms are most generally spread.

Where male individuals are found they only occur in very limited numbers as rare occurrences among the great majority of andro-monoecious individuals.

This also holds for the hermaphrodite plants, at any rate for *Daucus Carota*, *Sium latifolium* and *Heracleum Sphondylium*. Where these and andro-monoecious plants occur together the number of bisexuals is far less than that of the andro-monoecious ones. [3])

This general occurrence of andro-monoecious forms gives a very peculiar character to the family of the Umbelliferae. Nowhere in the vegetable kingdom these forms are so prominent as here.

In other families with species that are rich in forms, as the *Labiatae*, *Alsineae*, *Sileneae* and others, where gyno- and andro-monoecious and female and male forms occur together with bisexual ones, a similar preponderance of monoecious plants is not found with a single species.

The rule is there that where the three forms occur together the monoecious flowers are a minority with respect to the bisexual and unisexual ones.

Next is conspicuous with the monoecious Umbelliferae the great variety that may be observed in the occurrence of the male flowers in the umbels of different order and the many mutually different forms in which consequently one and the same andro-monoecious plant may occur.

Sometimes an individual is found which among the large number of bisexual flowers has a relatively small number of male ones, another time one in which the number of male flowers is not much

[1]) J. Staes. De bloemen van Daucus Carota L. Botanisch Jaarboek, Dodonaea Jaargang I. 1889. p. 132.

[2]) I shall soon treat elsewhere the different forms in which the Umbelliferae, occurring in this country, are met.

[3]) Male Umbelliferae and exclusively bisexual species are very rare also outside Europe. (See Drude Umbelliferae. Engler und Prantl. Die natürl. Pflanzenfamilien III. Teil. Abt. 8. p. 91).

less than that of the bisexual ones, and then again an individual in which the male flowers are more numerous than the others, and between these a long series of gradual transitions and intermediate forms is found.

Not unfrequently the number of male flowers is greatly in excess of the bisexuals. I met in this country plants of *Heracleum Sphondylium* in which the inner umbellules of the umbel of the first order and all other umbels of higher order were exclusively male and similar plants are also found of *Pastinaca sativa* and *Daucus Carota*. They are found spread among other individuals in which the proportion of male to bisexual flowers is more favourable to the bisexuals or where the number of males is even very small.

Some Umbelliferae are only known in an almost male form. *Echinophora spinosa* e. g. has one bisexual flower in the middle of the umbel; all other flowers are male. Also with *Meum athamanticum* and *Myrrhis odorata* we may observe in the specimens cultivated in this country in botanical gardens, how also there the bisexual flower is superseded, so that the umbellules often do not contain more than one such flower.

An investigation of the andro-monoecious Umbelliferae shows us at once that there is a certain regularity in the way in which the male flowers occur. In the first place, when they appear for the first time in an umbel of a certain order, their number as compared with that of the bisexual flowers increases as we come to umbels of higher order; and secondly, if in the peripheral umbellules some male flowers occur among the bisexual ones, their part in the constitution of the umbellules becomes greater as the umbellules are more distant from the periphery.

Of *Daucus Carota*, *Pastinaca sativa* and *Heracleum Sphondylium* whole series of specimens may be collected in the neighbourhood of my residence, beginning with such which in all the umbels contain only bisexual flowers up to forms which are almost or entirely (H. Sphondylium) male. Among these specimens are found in which the male flowers already appear in the very first umbel of the plant by the side of other specimens in which the andro-monoecious character only appears in the umbels of the second order or later still in those of the third or fourth order. Now it is a constant rule that if they appear for the first time in an umbel of a certain order they will also appear in the umbels that develop later and that their number in proportion to that of the bisexual flowers in the successive umbels goes on increasing.

Specimens which in no respect revealed their andro-monoecious character during the whole summer, which only late in summer produced male flowers in the umbels of the third or fourth order or sometimes entire male umbels, are found connected by intermediate forms with specimens which already in the very first umbels contain male flowers.

Concerning the part occupied by male flowers in the constitution of the peripheral and central umbellules, it must be remarked in the first place that with all Umbelliferae whose umbels reach a certain size, the peripheral umbellules consist of a larger number of flowers than those that occupy the middle part of the umbel. In some species those central umbellules may be very poor in flowers; with *Daucus Carota* the central umbellules often even consist of only one flower.

When it was stated that the part occupied in the umbellules by the male flowers becomes greater the more they are placed near the centre of the umbel, this must be so understood that as the umbellules become more distant from the periphery the number of bisexual flowers decreases and does so much more rapidly than the number of male flowers. Hence the inner umbellules are often entirely male while the outer ones bear a number of bisexual flowers.

This rule is not without exception, however. There are namely Umbelliferae in the umbels of which the central umbellule occupies the top of the principal axis of the umbel and may consequently be distinguished as the top-umbellule.

Such top-umbellules are especially found with *Carum Carvi* and *Oenanthe fistulosa* and occasionally, although not so regularly, also with *Daucus Carota*. For such a top-umbellule now the rule does not hold that the part occupied by the male flowers is greater than in the surrounding umbellules. Such an umbellule contains a greater quantity of bisexual flowers. With *Carum Carvi* I often found no male flowers in the top-umbellule when all others, as well the peripheral as the more inwardly situated umbellules had some of them. In other specimens the number of male flowers in this top-umbellule was smaller than in the other.

Of *Oenanthe fistulosa* the umbels of the second order are in this country much larger than those of the first order; they consist of five to eight umbellules and agree in their constitution almost entirely with that, indicated by SCHULZ for the umbellules of the first order. Here as a rule a top-umbellule can be very easily distinguished; it contains only a few (7 to 9) male flowers, but is for the rest entirely

hermaphrodite, while the side-umbellules are generally exclusively male.

With *Daucus Carota*, where the umbellule as was remarked above, often consists of no more than one flower, this latter is very often hermaphrodite, also when the surrounding umbellules consist entirely of male flowers.

It must still be remarked for the andro-monoecious Umbelliferae that both sorts of flowers as a rule occupy a fixed place in the umbellule.

In by far the most Umbelliferae the bisexual flowers are found near the edge and the male ones in the middle.

Only a few make an exception to this rule; with *Oenanthe fistulosa* and *Sanicula europaea* the opposite is found and with *Astrantia* the bisexual flowers as a rule occupy a definite zone between the peripheral and central male flowers. Advancing from the circumference to the centre we find there first one or two whorls of male flowers, then a whorl of bisexual ones and finally at the centre male flowers again.

But although it may be the rule for all other Umbelliferae that in all the umbellules, containing the two forms of flowers, the hermaphrodite ones are placed at the edge and the male ones in the middle, an exception must be made for those Umbelliferae which in the middle of the umbellules develop a top-flower, for this latter is as a rule bisexual.

Such top-flowers are e.g. regularly found with *Chaerophyllum* and with *Meum*; in each umbellule of *Chaerophyllum temulum* and *Meum athamanticum* bisexual marginal flowers and a bisexual top-flower are found and for the rest male flowers.

Also with *Aegopodium Podograria*, *Carum Carvi* and *Daucus Carota* bisexual top-flowers are found in the umbellules, but in these species this top-flower is not always found in all umbellules.

No extensive argument will be needed to understand that the two forms of flowers, found in the same individual of the plants mentioned, may be considered, like the two flowers of a cleistogamic plant, as two antagonistic characters which mutually exclude each other and that consequently these plants may be compared with ever-sporting varieties, originated by mutation, the existence of which was shown by DE VRIES.

Every andro-monoecious Umbellifera of which we compare a number of individuals among themselves, affords an opportunity for noticing that the two antagonistic characters evidently fight for

supremacy, in which combat now one, then the other gains an advantage.

But if of a species which is rich in forms we mutually compare a fairly complete series of andro-monoecious forms, we are struck by the circumstance that between these and the ever-sporting varieties known until now, there is this important difference that while with other ever-sporting varieties the original specific character is always more conspicuous than the racial character, here very often the opposite takes place.

We met in what precedes plants like *Myrrhis odorata*, *Meum athamanticum* or forms of *Pastinaca sativa*, *Heracleum Sphondylium* and *Daucus Carota*, where the specific character had been entirely superseded by the racial character, and this raises the question whether the andro-monoecious Umbelliferae, looked upon as races originated by mutation, must be placed on a line with the above-mentioned gyno-monoecious *Satureja hortensis* and other ever-sporting varieties.

We know from the theory of mutation that the interaction of two antagonistic characters may show itself in more than one way and that a character originated by mutation may be inherited in a different degree in various plant-species, by which process various races are formed.

To a race in which the anomaly comes only little to the front, much less than the normal character, and which consequently is hereditary in a small degree only, DE VRIES has given the name of a half-race, and the abnormal character he has called *semi-latent*. That, however, among these half-races important differences may occur in the measure in which the character is semi-latent, clearly appeared from the statistical investigation of the half-races, e.g. of *Trifolium incarnatum quadrifolium* and *Trifolium pratense quinquefolium*.

It may be imagined that there exist races in which the two antagonistic characters possess nearly the same degree of heredity so that then it is often difficult, under favourable circumstances, to settle whether the specific or the racial character is more prominent and sometimes even, when the conditions of life are very favourable, the anomaly gets the upper hand. In such a race as well the specific character as the anomaly are then to be considered as *semi-active*. The statistical investigation of the anomalies has not yet revealed that such races really exist.

But it may be further imagined that between these latter races which DE VRIES called middle-races and the constant varieties, in which the specific character is latent and the anomaly active, there

exist still other races in which the *normal character* is semi-latent to a different degree.

De Vries thinks such cases possible, but until now they have not yet been noticed [1]). Now the question arose to me whether in the andro-monoecious Umbelliferae we may not have such races in which the specific character has become semi-latent? [2])

Let us start our speculations with one of those Umbelliferae of which besides andro-monoecious ones also hermaphrodite and male forms are known, e. g. *Heracleum Sphondylium*.

As was remarked above, *Heracleum Sphondylium* appears in a great part of Middle Europe as a hermaphrodite plant. In the environs of Neu-Ruppin at the same time forms are however found which are only bisexual in the umbels of the first order, whose umbels of the second order are composed on half bisexual and half male umbellules and whose umbels of the third order are exclusively male, and which in consequence may be considered to produce about as many male as bisexual flowers.

In this country now I found besides the hermaphrodite and the Neu-Ruppin middle forms a great variety of forms which may be considered either as gradual transitions of those middle forms to perfectly hermaphrodite ones or as gradual transitions of those middle forms to perfectly male individuals, which latter occur also in this country.

If we now *for the present* consider this andro-monoecious plant which is so rich in forms as an ever-sporting variety, and if we compare its properties with those of *Trifolium pratense quinquefolium*, which has first been extensively dealt with by de Vries, and later has been investigated in all its details by Miss Tammes [3]), so that of this race the properties are most completely known, then we begin with asking what peculiarities *Heracleum* should present if its monoecious form represented an ever-sporting variety.

Then we should observe:

1. that a strongly developed specimen, e.g. a plant with umbels of the first to the fourth order, produces more male flowers than an individual which has not succeeded in getting beyond the formation of umbels of the first and second order.

---

[1]) De Vries, Mutationstheorie, I, p. 424.

[2]) In my article on cleistogamic plants I already briefly raised the question whether Ruellia tuberosa, Impatiens noli tangere, Impatiens fulva, Amphicarpaea monoica, Viola spec. div. are not in this condition.

[3]) Bot. Zeit. 1ste. Abt., Heft XI, 1904.

2. that plants on fertile soil produce on the whole more male flowers in proportion to the bisexual ones than plants on less fertile soil.

3. that the male flowers only appear at a stage in which the plant has grown stronger, that they gradually increase in number as the individual grows stronger and gradually decrease in number again when the plant has passed its highest point of development.

4. that in each umbel as well as in each umbellule which contains both forms of flowers, the male flowers are preferably found in those places which are most favourable with respect to nutrition.

It is not difficult to show that observation does *not* confirm these four points.

Let us in the first place consider point 4.

There can be no doubt that (excepting the just mentioned terminal umbellules and terminal flowers) the peripheral umbellules are more favourably placed with regard to nutrition than the more inwardly situated umbellules, and that in each umbellule the flowers at the circumference also occupy a more favourable position than those in the middle. This is seen not only by the inner umbellules being less rich in flowers but also in the flowers becoming smaller the further they are distant from the periphery; often the central flowers do not reach their normal development or the setting of the fruit does not take place. We see here the same with the umbels as with long-drawn inflorescences like those of *Capsella Bursa pastoris* or *Pisum sativum*, that namely the last-formed flowers, at the top of the inflorescence, no longer reach their normal development on account of insufficient nutrition. Further every umbellule (not only a mixed one but also a purely hermaphrodite one) allows us to notice that the peripheral flowers are ahead of the central ones in their development.

And now we see with all Umbelliferae without exception:

that the peripheral umbellules retain their bisexual character longest,

that the male flowers always occur first at the centre of the umbel,

that where the umbellules are mixed, the number of bisexual flowers always decreases from the periphery to the centre,

that the inner umbellules often are already entirely male when the outer ones still contain bisexual flowers, and

that everywhere, except with *Oenanthe fistulosa*, *Sanicula europaea* and *Astrantia* the marginal flowers in the umbellules are bisexual and the central flowers male[1]).

[1]) I think an explanation may be found for the anomalous behaviour of these three genera. I cannot dwell on this point, however, in this short communica-

In other words, we may say *that as well in the umbel as in the umbellule the bisexual flowers always occupy the place which is most favourable with respect to nutrition.*

That terminal umbellules and flowers are placed most favourably is evident; it can be readily explained why a top-umbellule is often richer in bisexual flowers than other umbellules from the centre and why as a rule the top-flower of the umbellule is hermaphrodite.

That this position is by far the most advantageous can also be inferred from the fact that often the top-flower is the only bisexual one of the whole umbellule. So with *Meum athamanticum* e.g. it is very often found that in the umbels of the second order, the 6—8 inner umbellules possess no bisexual flowers at all; the only bisexual flower of these umbellules is the top-flower.[1])

So we see exactly the opposite from what we should observe if the andro-monoecious plant represented an ever-sporting variety like *Trifolium pratense quinquefolium.* It is not the *male* flower — the *anomaly* — which is preferably found in the best places, but the *bisexual* flower, and on further examination of the above points 1, 2 and 3 we shall again see how it is this latter that depends on the nutritive conditions and in all respects behaves like a character in a semi-latent condition opposed to the active condition of the anomaly.

I pointed out already that with all andro-monoecious Umbelliferae the umbel of the first order shows the anomaly least.

With very many forms the male flower appears first in the umbels of the second order, with others in those of the third order, and sometimes it is the umbel of the fourth order in which the male flower appears first.

But where these flowers are already observed in the umbels of the first order their number is there always less than in the umbels of the second and higher orders.

*The umbel of the first order consequently retains in all andro-monoecious Umbelliferae the pure racial character longest.*

If we remember that the umbel of the first order is at the same time the terminal umbel of the plant and is extremely favourably placed at the end of the principal axis with regard nutrition, we cannot wonder at this, bearing in mind what was said when

---

tion. I shall return to it elsewhere when exposing the differences between the forms occurring in this country and those that have been observed in other parts of Europe.

[1]) This reminds us of what may be noticed with *Echinophora spinosa.* Vide supra.

discussing point 4. We find the already stated conception confirmed that *the bisexual flower, being in a latent condition with respect to the anomaly, preferably occurs in the most favourable places.*

We may also assume that the plant during the flowering of its top-umbel, which only occurs after it has reached its full vegetative development, is also in the strongest stage of its growth, in a stage in which a good part of its nutritive material may be spent on the development of its top-umbel, while all umbels that bud forth later, are in less favourable conditions, first on account of their being placed on lateral axes of the second or higher order and secondly because a very great part of the nutritive material is spent on the ripening of the fruit of the first umbel during the development of the umbels of the second or at any rate higher orders. This would explain why in the umbel of the second order the semi-latent bisexual flower is no longer prominent in the same degree as in the terminal umbel, and why in the umbels of the third and fourth order it more and more gives way before the racial character.

This also explains why in very strong specimens the male flowers first appear in the umbels of the third order, and why often with *Sium latifolium*, *Daucus Carota* and others, not until late in summer, when the plant has already passed its highest point of development, male flowers and even male umbels appear in plants which in their umbels of the first and second or first, second and third order have exclusively produced bisexual flowers.

That in fact strongly developed specimens produce more bisexual flowers than weak specimens was already noticed by Mac Leod. With strong specimens — he says in his note on *Aegopodium Podagraria* — the umbels of the first order and with very strong specimens also those of the second order consist almost exclusively of hermaphrodite flowers, while with ordinary specimens the umbellules in the umbels of the first order consist partly and in those of the second order exclusively of male flowers. Also Schulz made the same remark with *Torilis Anthriscus* and *Pimpinella saxifraga* and personally I found the justness of his remark repeatedly confirmed with *Pimpinella magna*, *Aegopodium Podagraria*, *Aethusa Cynapium*, *Astrantia major* etc.

If now finally the numerical relations of the two flower-forms are examined in umbels of such species as are found in large numbers on soils of different constitution and fertility, the examination at once shows that the number of bisexual flowers in a fertile place is considerably greater than in a less fertile one. *Anthriscus silvestris* and *Chaerophyllum temulum* are plants which in our country are

very general as well on sandy soil (at the edge of the dunes) as on fertile claygrounds. Both plants can be best judged by the constitution of the umbels of the second order.

Of *Anthriscus silvestris* the average constitution is:

| | on sandy soil | on clay ground |
|---|---|---|
| of the six outer umbellules | 4-5☿+11-13♂ | 7-10☿+3-4♂ |
| of the seven inner umbellules | 2-4☿+ 8-11♂ | 6-7☿+4-7♂ |

And of *Chaerophyllum temulum*:

| | | |
|---|---|---|
| of the outer umbellules | 15☿+10♂+1☿ | 20☿+7♂+1☿ |

while the 2 or 3 innermost umbellules of the plants on sandy soil are entirely male.

So the results are in perfect agreement with my observations on the influence of the fertility of the soil on the appearance of chasmogamic flowers with *Ruellia tuberosa* at Batavia and with those of GOEBEL on the chasmogamic flowers with *Impatiens noli tangere* in places of different fertility near Ambach [1]).

From what has been communicated here it appears that the andromonoecious Umbelliferae in the natural state have the character of ever-sporting varieties in which the racial character, the bisexual flower, is in a semi-latent condition.

By assuming this it becomes clear why the anomaly shows itself least in the terminal umbel, why, after it has once appeared, it increases in number in the umbels of higher order, why in each umbel the number of hermaphrodite flowers decreases from the periphery to the centre, why in each umbellule the bisexual flowers are placed at the circumference and the male ones at the centre and why with those species in which the umbels have a top-umbellule, this latter often has again relatively more bisexual flowers than the surrounding umbellules and finally why, where in the umbellules a top-flower is found, this is as a rule bisexual and holds out longest when the umbellules grow more and more male, so that it often still occurs in such umbellules where the bisexual marginal flowers have already had to give way to the male ones.

Although I am of opinion that many things plead for my conception, yet I am perfectly aware that *certainty* about the true nature of the race, about the influence of fluctuating variability on the numerical relations between bisexual and male flowers, about the question whether perhaps locally different varieties or ever-sporting varieties

---

[1]) GOEBEL. Die kleistogamen Blüten und die Anpassungstheorien. Biol. Centralbl. Bd. XXIV. No. 24, p. 770.

may exist of one and the same Umbellifer and other related questions can only be obtained by culture experiments and statistical investigation.

Yet I thought it worth while to communicate these observations although they must only be considered as an exposition of the grounds why culture experiments were undertaken. It may be useful to indicate these grounds, first because they support my conception about the racial character of many cleistogamic plants, and further because in my opinion we may certainly expect that besides monoecious and cleistogamic plants, other plants in the natural state will turn out to have the character of races originated by mutation, so that this communication may to some extent draw attention to this point.

The culture experiments will from the nature of the case occupy a few years.

In the Ergänzungsband of Flora 1905, Heft I, p, 214, GOEBEL communicates as a sequel to his paper "Die kleistogamen Blüten und die Anpassungstheorien" the results of his continued culture experiments with cleistogamic species of *Viola*. The results of his experiments confirm his formerly pronounced opinion that the appearance of a cleistogamic or chasmogamic flower depends entirely on *nutritive conditions*. If these are favourable the chasmogamic flower is seen to appear; in the opposite case the cleistogamic one appears.

I communicated in my former article my objections to this conception. I will now only remark that the influence of the nutritive conditions shows itself in such a way that with favourable conditions the *semi-latent* character is developed, and with unfavourable is suppressed.

Now if in GOEBEL's experiments the chasmogamic flowering is suppressed when the plant is under unfavourable conditions, this is because *Viola* is an ever-sporting variety in which the chasmogamic flower is in a semi-latent condition. If the cleistogamic *Viola* belonged to one of the other ever-sporting varieties, if e.g. it were an ever-sporting variety like the gyno-monoecious form of *Satureja hortensis* or *Trifolium pratense quinquefolium* in which the *anomaly*: (the female flower and the composite leaf) is in a semi-latent condition, then under favourable nutritive conditions the anomaly, the *cleistogamic* flower and under less favourable conditions the *chasmogamic* flower would be fostered.

**Zoology.** — *"The uterus of Erinaceus europaeus L. after parturition"*. By Prof. H. STRAHL, of Giessen. (Communicated by Prof. A. A. W. HUBRECHT).

(Communicated in the meeting of March 31, 1906).

Through the obliging kindness of my colleague Prof. HUBRECHT, to whom I owe my sincere thanks, I was enabled to continue my researches on the involution of the uterus post partum with a species which, as far as I know, had not yet been studied in this respect. The examination of a larger number of uteri of Erinaceus europaeus L. made it possible sufficiently to investigate the regressive development in question.

In the pregnant uterus of the hedgehog shortly before parturition, pretty large foetal chambers are found, as was shown by HUBRECHT's extensive investigations. These chambers are entirely lined with epithelium which extends a little under the edges of the discoid placenta, the relative size of which is not very large. This placenta consequently belongs to the stalked ones, although the stalk is a very broad one.

The wall of the uterus of a hedgehog which was killed immediately after parturition is accordingly almost entirely covered with an epithelium which proved to consist of high, cylindrical cells. A layer of epithelium is only wanting in a small antimesometral region which is characterised as the site of the placenta by the large vascular stumps.

Excepting the specimen just mentioned the time post partum could not be determined in my preparations. So I had to arrange them in a series according to the thickness of the uteri, beginning with such as were still very thick and admitted of a determination of the number of former foetal chambers by swellings corresponding to the placental places and ending with others the appearance of which did not reveal any traces of pregnancy. The sections obtained from such uteri were in good agreement with each other and gave a sufficient idea of the various stages of involution.

I will not give here a detailed description of the phases of the retrogade development but only remark that the essential changes occur in the connective tissue of the uterine mucous membrane and in the glandular apparatus. The surface epithelium which with many animals (e.g. with Putorius furo) undergoes considerable changes of form, here shows these to a relatively smaller extent. They are limited to the casting off of superfluous parts and to the change of larger cells into smaller ones.

The epithelial defect of the placental spot is covered by epithelium advancing from the edges by a similar process as has become known of late years for a number of other mammals. Since a spot without epithelium is found in several stages, it must be assumed that the covering of the gap does not take place so rapidly as e.g. in many Rodents.

Characteristic for the connective tissue is the great abundance of liquid in it; after parturition it appears to be of a loose irregular texture and contains a considerable number of large blood- and especially lymph-vessels, the former especially in the placental spot, the latter spread over the whole mucous membrane. In this connective tissue during the first period following parturition only small and irregularly shaped glands are found, with a low epithelium. These glands occupy little place in the pretty thick mucous membrane.

In the completely retrograde uterus I find a mucous-connective tissue which is not particularly strong and is rich in cells; in this long glands reach in a very graceful and regular arrangement from the inside of the uterus to the musculature, while larger blood- and lymph-vessels are lacking in it. (see fig. 1 in HUBRECHT's Studies in Mammalian Embryology. Quart. journ. of micr. sc. vol. XXX. new ser.). A comparison of these two stages, representing the beginning and the end of the involution, shows the direction of the involution. It consists, not to speak of the just mentioned minor changes in the epithelium, in the connective tissue becoming more compact, the total calibre becoming considerably less, and in a re-arrangement of the glandular apparatus which is probably accompanied by a new-formation, but certainly with a re-arrangement and considerable lengthening of the single glandular tubes.

In the connective tissue it is not so much the single cells which change (as is e.g. conspicuously the case with the female dog post partum) as there is a clear indication that intercellular substances diminish, which finally leads to a consolidation of the whole tissue.

At the same time the swollen lymph-vessels become smaller and narrower as well as the stumps of the torn blood-vessels in the placental spot, the trombi of which organise themselves. The retrogression at the placental spot takes place distinctly more slowly than in the remaining mucous membrane so that the placental spot is still recognised as something particular when the gap in the epithelium has become completely covered.

The return of the glands to their regular form takes still more time than that of the connective tissue, perhaps its last phase only sets in with a new rut.

*Comparing the puerperal involution of the uterus of the hedgehog with the same process as it occurs in other mammals, hitherto studied, we may state that in this respect the hedgehog occupies an intermediate position between Rodents and Carnivora. It stands near the former in the way in which the epithelium regresses, near some of the latter in the regression of the layer of connective tissue, although in this respect the analogy is not complete.*

The more accurate details of the involutional processes of which a short sketch is given here, will be published elsewhere.

**Physics.** — "*Magnetic resolution of spectral lines and magnetic force*". By Prof. P. ZEEMAN. (First part).

The intensity of a magnetic field may be defined by the amount of splitting up of a given spectral line emitted by a source placed in the field.

The distance of the outer components of a triplet can be measured with great accuracy. The components of a line resolved by the action of magnetism are of the same width as the original line and the high degree of accuracy obtainable in the measurement of spectrum photographs is generally known.

We may call two magnetic intensities equal, when producing equal amounts of separation of a spectral line, and we may call two differences of magnetic intensities equal, when the changes of the distances of the components are the same. In this way we obtain a scale of magnetic forces, the zero point and the magnitude of the units can still however be chosen arbitrarily. All conditions necessary for the *indirect* comparison of different intensities of a quantity are fulfilled. [1])

In this method of measuring magnetic forces we adopt a natural unit of magnetic force.

In applying the specified method we need not know the functional relation between magnetic force and magnetic separation of the spectral lines. It is sufficient to know that this function is one-valued. The most accurate measurements of the present time [2]) and also theory render it extremely probable that the separation of the spectral lines is proportional to the intensity of the field wherein the source of light is placed. If this simple relation be

[1]) Comp. RUNGE, Maass und Messen. Encyclopädie der mathematischen Wissensch. Bd. V. I. 1903.

[2]) See specially: A. FÄRBER, Über das Zeeman-Phänomen. Ann. d. Phys. 9 p. 886. 1902.

the true one, then our scale of magnetic forces is identical with the one commonly used.

We may then deduce from a given separation of a well-defined spectral line the strength of a field in absolute measure, the constant of reduction being once for all determined.

In the measurements of FÄRBER [1]) relating to the lines 4678 Cd and 4680 Zn (produced by a spark between zinc-cadmium electrodes) the constant of reduction could be determined with a probable error of far less then $^1/_{100}$.

This method and all methods used till now for measuring magnetic fields, give the intensity in a point. Or rather the mean value in a small area (often rather extensive) or in a small space is considered to be the intensity in a point of that area or of that space.

The magnetic separation of the spectral lines enables us *to measure simultaneously the magnetic force in all points belonging to a straight line.*

In my experiments vacuum tubes charged with some mercury and excited by a coil were used. The tubes had capillaries of 8 cm. length, the interior diameters varying between $^1/_4$ and $^1/_2$ mm. The shape of the tubes was that given by PASCHEN [2]), also used by RUNGE and PASCHEN in their investigation concerning the radiation of mercury in the magnetic field.

A very moderate heating is required for the passage of the discharge, the light in the capillary is then fairly intense, it becomes very brilliant as soon as the tube is placed in the magnetic field.

It was noticed that for a given vapour density there exists a definite intensity of field for which the luminosity is a maximum. This is easily seen when putting on the current of a DU BOIS half ring electromagnet. Owing to the large inductance (relaxation time 50″) the intensity of the field rises gradually. If the vapour density in the tube is not too high, there is clearly one moment of maximum luminosity.

If with a given field the density of the vapour is well chosen, then only a very moderate heating of the tube is sufficient for keeping it luminous.

When the tube is placed between the conical poles of a DU BOIS electromagnet and in a plane perpendicular to the line joining the poles, there is of course a different field intensity in every point of

1) FÄRBER. l. c.

2) PASCHEN, Eine Geisslersche Röhre zum Studium des ZEEMAN-effectes. Physik. Zeitschr. p. 478. I. 1900.

the tube. Analysing the light of the different points of the tube with a spectroscope, we find of course a different magnetic separation for every point.

We can however spectroscopically analyse *simultaneously* the light of all points of the tube.

We have only to focus an image of the tube upon the slit of the spectroscope. This spectroscope must satisfy one condition. This condition is that to every point of the slit there corresponds one point of the spectral image. In the case of a prism spectroscope, of an echelon spectroscope, and of a plane grating spectroscope, this condition is clearly fulfilled, but the concave grating mounted in ROWLAND's manner forms an exception. The use of the concave grating necessitates in our case the employment of the method proposed by RUNGE and PASCHEN [1]).

My experiments were made in the above manner.

To illustrate this method I shall take the blue line of mercury (4359), which divides into a sextet.

The distribution of the magnetic force in a plane perpendicular to the axis of a DU BOIS electromagnet with a distance of 4 mm. between the poles is mapped out in a spindle-shaped magnetogram, of which a part is reproduced in Fig. 1. This figure is from a negative enlarged 9 times. We may extinguish by means of a Nicol the light of the inner components. At both sides two narrow lines remain. Fig. 2 is a *natural* size reproduction of a magnetogram taken under the specified conditions. The duplication of the outer components is lost in the reproduction. The extension of the field, mapped out by this magnetogram, may be better understood if I observe that 1 mm. in the focal plane of the spectroscope corresponds to 1.80 mm. in the plane between the poles or 1 mm. in the latter plane to 0,556 mm. of the negative. Hence in Fig. 1 5 mm. corresponds to 1 mm. between the poles. The complete magnetogram gives the magnetic force in a line, 30 mm. in length. Using a lens of shorter focus we can represent, of course, a greater part of the field. In the middle of the field the magnetic force is about 24,000 C. G. S. A *comparison* of field strengths can be made with a decidedly higher degree of accuracy than that which is given above for an absolute measurement.

The method set forth above will be applied, of course, only in difficult cases. As long as our spectroscopes of great resolving power are rather cumbersome, no practical application of the method is possible.

In many cases there will be great advantage in selecting a spectral line which is tripled in the field.

[1]) KAYSER. Handbuch Bd. I, p. 482.

Fig. 1.

Fig. 2.

The magnetisation of the spectral lines enables us to determine the maximum value of the force with phenomena varying rapidly with the time, and with non-uniform fields.

In some cases it is of great importance to follow the behaviour of a spectral phenomenon with different strengths of field. The above described method might then be called *the method of the non-uniform field.*

In a future communication I hope to study in this manner the *asymmetry* of the separation of spectral lines in weak magnetic fields, predicted from theory by VOIGT. On a former occasion I have communicated some experiments giving rather convincing evidence of the existence of this asymmetry [1]).

In the mean time, I think that the developments lately given by LORENTZ [2]) make it desirable to corroborate the reasons for accepting the existence of this extremely small asymmetry.

**Mathematics.** — *"Some properties of pencils of algebraic curves".* By Prof. JAN DE VRIES.

§ 1. Let $A$ be one of the $n^2$ basepoints of a pencil $(c^n)$ of curves $c^n$ of order $n$, $B$ one of the remaining basepoints. If we make to correspond to each $c^n$ the right line $c^1$ touching $c^n$ in $A$, then we get as product of the projective pencils $(c^n)$ and $(c^1)$, a curve $T_1$ of order $(n+1)$ forming the locus of the tangential points of $A$, i. e. of the points which are determined by each $c^n$ on its tangent $c^1$. This *tangential curve* has in $A$ a threefold point where it is touched by the inflectional tangents of three $c^n$ having in $A$ an inflection; it has been considered for the first time by EMIL WEYR (Sitz. Ber. Akad. in Wien, LXI, 82).

I shall now consider more in general the locus $T_m$ of the $m^{\text{th}}$ tangential points of $A$. The order of this curve is to be represented by $\tau(m)$, whilst $\alpha(m)$ and $\beta(m)$ are to indicate the number of branches which $T_m$ has in $A$ and $B$.

Prof. P. H. SCHOUTE has drawn my attention to a paper inserted by him in the Comptes Rendus de l'Académie des sciences, tome CI, 736, where the corresponding curve is treated for a cubic pencil. I found that the numbers obtained there for $n = 3$ appear from the results to be deduced here.

---

[1]) ZEEMAN. These Proceedings, December 1899.

[2]) LORENTZ. These Proceedings, December 1905.

To determine the functions $\tau(m)$, $\alpha(m)$ and $\beta(m)$ I shall make use of an auxiliary curve already used by WEYR, which might be called the *antitangential curve* of $A$. It contains the groups of $n(n-1)-2$ points $A_{-1}$, having $A$ as tangential point; so it passes three times through $A$ and once through all points $B$. So it has $(2n^2-n)$ points in common with any $c^n$, from which it is evident that it is of order $(2n-1)$.

§ 2. The $(m-1)^{\text{th}}$ tangential curve $(A^{m-1})$ of $A$ is cut by the antitangential curve $(A^{-1})$ of $A$, save in the base points, in the points $A^{(m-1)}$ having $A$ as tangential point. Their number amounts to three less than the number of tangents which $T_m$ has in $A$, so $\alpha(m)-3$; for, on the three $c^n$ which have in $A$ an inflection $A$ coincides with one of its $m^{\text{th}}$ tangential points.

The three inflectional tangents being also tangents of the curve $(A^{-1})$, the tangential curve $(A^{m-1})$ and the antitangential curve $(A^{-1})$ have $3\alpha(m-1)+3$ points in common in $A$. In each basepoint $B$ lie $\beta(m-1)$ points of intersection. So

$$(2n-1)\,\tau(m-1)=\alpha(m)+3\alpha(m-1)+(n^2-1)\,\beta(m-1) \quad . \quad (1)$$

A second relation is found by noticing that $(A^{m-1})$ has with the antitangential curve of $B$, save the basis, the $\beta(m)$ points in common for which $B$ is an $m^{\text{th}}$ tangential point. In $B$ lie $3\beta(m-1)$ points of intersection, $\alpha(m-1)$ points of intersection lie in $A$, $\beta(m-1)$ in each of the other basepoints. So

$$(2n-1)\,\tau(m-1)=\beta(m)+\alpha(m-1)+(n^2-1)\,\beta(m-1) \quad . \quad (2)$$

With any $c^n$ the locus $T_m$ has, save the basis, only the $(n-2)^m$ points $A^{(m)}$ in common; so

$$n\,\tau(m)=\alpha(m)+(n^2-1)\,\beta(m)+(n-2)^m \quad . \quad . \quad . \quad (3)$$

§ 3. To find a homogeneous equation of finite differences for the determination of $\tau(m)$ I eliminate from the three obtained relations the quantities $\alpha(m)$ and $\beta(m)$, and I find

$$n\tau(m)=n^2(2n-1)\tau(m-1)-(n^2+2)\{\alpha(m-1)+(n^2-1)\beta(m-1)\}+(n-2)^m.$$

Here the expression within braces can be replaced on account of (3) by $n\tau(m-1)-(n-2)^{m-1}$. Then

$$\tau(m)=(n^2-n-2)\,\tau(m-1)+(n+1)(n-2)^{m-1} \quad . \quad . \quad (4)$$

So

$$\tau(m-1)=(n^2-n-2)\,\tau(m-2)+(n+1)(n-2)^{m-2} \quad . \quad (5)$$

Equations (4) and (5) finally furnish

$$\tau(m)-(n-2)(n+2)\,\tau(m-1)+(n-2)^2(n+1)\,\tau(m-2)=0 \quad (6)$$

To determine a particular solution $\tau(m) = x^m$ we have

$$x^2 - (n-2)(n+2)x + (n-2)^2(n+1) = 0,$$

therefore

$$x = n^2 - n - 2 \text{ or } x = n - 2.$$

Consequently the general solution is

$$\tau(m) = c_1(n^2 - n - 2)^m + c_2(n-2)^m.$$

To determine the constants $c_1$ and $c_2$ I substitute in (4) the known values $(n+1)$ of $\tau(1)$ and $(n+1)(n^2-4)$ of $\tau(2)$.

Now

$$n + 1 = c_1(n^2 - n - 2) + c_2(n-2),$$
$$(n^2-4)(n+1) = c_1(n^2 - n - 2)^2 + c_2(n-2)^2.$$

Finally we find by elimination of $c_1$ and $c_2$

$$\tau(m) = (n+1)(n-2)^{m-1}\frac{(n+1)^m - 1}{n} \quad . \quad . \quad . \quad . \quad (7)$$

From (1) and (2) ensues

$$\alpha(m) - \beta(m) = -2\{\alpha(m-1) - \beta(m-1)\},$$

so

$$\alpha(m) - \beta(m) = (-2)^{m-1}\{\alpha(1) - \beta(1)\} = -(-2)^m \quad . \quad . \quad (8)$$

Making use of (3) and (7) we now find

$$n^2\alpha(m) = (n-2)^{m-1}\{(n+1)^{m+1} - 2n + 1\} - (n^2-1)(-2)^m \quad . \quad (9)$$
$$n^2\beta(m) = (n-2)^{m-1}\{(n+1)^{m+1} - 2n + 1\} + (-2)^m \quad . \quad . \quad . \quad . \quad (10)$$

§ 4. For $m = 2$ we find $\alpha(2) = n^2 + n - 9$; as $A$ is inflection for three curves $c_n$, there are therefore $(n^2 + n - 12)$ curves on which $A$ coincides with its second tangential point. From this ensues the wellknown result that $A$ is point of contact of $(n+4)(n-3)$ double tangents.

In a former paper [1]) I have brought into connection the locus of the points of contact $D$ of the double tangents with the locus of the points $W$ in which a $c^n$ is cut by its double tangents. To determine, how often a point $D$ coincides with one of its tangential points $W$ I consider the correspondence of the rays $d = OD$ and $w = OW$ which the correspondence $(D, W)$ forms in a pencil with vertex $O$.

As the curves $(D)$ and $(W)$ are of orders $(n-3)(2n^2 + 5n - 6)$ and $\frac{1}{2}(n-4)(n-3)(5n^2 + 5n - 6)$, to each ray $d$ correspond $(n-4)(n-3)(2n^2 + 5n - 6)$ rays $w$ and to each ray $w$ correspond $(n-4)(n-3)(5n^2 + 5n - 6)$ rays $d$.

---

[1]) "On linear systems of algebraic plane curves." Proc. April 22 1905, Vol. VII (a), p. 711.

Because each of the $2n(n-2)(n-3)$ double tangents out of $O$ represents $2(n-4)$ coincidences $d \equiv w$, the number of coincidences $D \equiv W$ is represented by

$$(n-4)(n-3)(2n^2+5n-6)+(n-4)(n-3)(5n^2+5n-6)-$$
$$-4(n-4)(n-3)(n-2)n = 3(n-4)(n-3)(n^2+6n-4).$$

*In a pencil* $(c^n)$ *we find that* $3(n-4)(n-3)(n^2+6n-4)$ *curves have an inflection, of which the tangent touches the curve in one other point more.*

In the paper quoted above I thought I was able to determine this number out of the points of intersection of the curves $(D)$ and $(W)$; here I overlooked the fact that a point of contact of a double tangent can be tangential point $W$ of another double tangent.

§ 5. To find the number of threefold tangents I consider the correspondence between the rays projecting out of $O$ two points $W$ and $W'$ lying on the same double tangent. The characterizing number of this symmetric correspondence is evidently equal to $\frac{1}{2}(n-4)(n-3)(5n^2+5n-6)(n-5)$, whilst each double tangent borne by $O$ replaces $2n(n-2)(n-3)(n-4)(n-5)$ coincidences. The number of coincidences $W \equiv W'$ amounts thus to

$$(n-5)(n-4)(n-3)(5n^2+5n-6-2n^2+4n).$$

As each threefold tangent bears three of these coincidences we have the property:

*In a pencil* $(c^n)$ *we find that* $(n-5)(n-4)(n-3)(n^2+3n-2)$ *curves have a threefold tangent.*

§ 6. In my paper indicated above I have tried to determine the number of undulation-points out of the points of intersection of the inflectional curve $(I)$ with the locus of the points $(V)$ which $c^n$ determines on its inflectional tangents. As each inflection which is also tangential point of another inflection is common to $(I)$ and $(V)$, the number found elsewhere is too large. The exact number I can determine by means of the correspondence between the rays $OI$ and $OV$.

As the orders of $(I)$ and $(V)$ are $6(n-1)$ and $3(n-3)(n^2+2n-2)$ and each of the $3n(n-2)$ inflectional tangents drawn from $O$ replaces $(n-3)$ rays of coincidence, we get for the number of coincidences $I \equiv V$

$$6(n-1)(n-3)+3(n-3)(n^2+2n-2)-3n(n-2)(n-3)=6(n-3)(3n-2).$$

*In a pencil* $(c^n)$ *we find that* $6(n-3)(3n-2)$ *curves have a four-point tangent.*

§ 7. The curve of inflections $(I)$ and the bitangential curve $(D)$ have in each of the $3(n-1)^2$ nodes of $(c^n)$ in common a number of $2(n-3)(n+2)$ points.

For, out of a node we can draw to the $c^n$ to which it belongs $(n^2-n-6)$ tangents, to be regarded as double tangents, whilst each node of a $c^n$ is at the same time node of $(I)$.

In each basepoint lie moreover $3(n+4)(n-3)$ points of intersection (§ 4). The remaining points common to $(D)$ and $(I)$ are the inflections of which the tangent touches the $c^n$ once more (§ 4) and the undulation-points (§ 6) where the two curves touch each other.

Indeed, we have

$$6(n-1)^2(n-3)(n+2)+3n^2(n+4)(n-3)+3(n-4)(n-3)(n^2+6n-4)+$$
$$+12(n-3)(3n-2)=6(n-1)^2(n-3)(n+2)+3(n-3)(2n^3+6n^2-16n+8)=$$
$$=6(n-1)(n-3)(2n^2+5n-6),$$

and this is the product of the orders of $(I)$ and $(D)$.

**Physiology.** "*On the strength of reflex stimuli as weak as possible.*" By Prof. H. ZWAARDEMAKER. (Report of a research made by D. I. A. VAN REEKUM).

(Communicated in the meeting of March 31, 1906).

Investigated were chemical, thermal, mechanical and electrical stimuli, which partly acted upon the skin partly on the sensible nerves of the animals, which were experimented on.

§ 1. The chemical stimuli were applied by immerging the hind-leg of a winterfrog in a little bowl with a solution of sulphuric acid varying from $^1/_4$ to $^1/_{32}\,^0/_0$ $\left(\frac{n}{20}\text{ to }\frac{n}{160}\right)$. The spinal cord system was withdrawn in the usual way from the influence of the cerebrum. After the experiment the legs were washed with distilled water and the experiment repeated after a pause of 5 minutes. Neglecting the preliminary reflex, only a complete reflex was considered as a positive result. After-reflexes and general movements did only show themselves when rather strong concentrations were used.

As a rule a $^1/_{17}\,^0/_0$ $\left(\frac{n}{85}\right)$ solution of sulphuric acid may be accepted as the minimum stimulus which still produces reflexes. The reflex-

time at an immerging of the two legs was 10 seconds, at an immerging of one leg 22 seconds.

It was calculated how much sulphuric acid disappeared in the skin of the frog, when $^1/_{17}$ % sulphuric acid $\left(\frac{n}{85}\right)$ was used, respectively how much was fixed by the excretion-products. This occurred by titrating the immerging liquid with caustic soda (methylene orange as indicator) before and after a series of 20 singular reflexes.

Then it appears that about $^1/_{15}$ of the total quantity of the used sulphuric acid has been bound. Supposing the heat of reaction of 2 aequivalents natron and 1 aequivalent sulphuric acid to be 31,4 great calories and supposing that our sulphuric acid has been bound in a reaction of this kind then the heat of reaction of the chemical process pro singular reflex, reckoned over the whole immerged surface of the skin, amounts to 1,37 gram-calorie. It is evident that only a small part of this supposed reaction can have taken place in or near the terminations of the nerves and that this value of 1,37 gram-calorie must be also a limit under which is situated the heat of reaction.

This amount may surpass the real value of the reflex-stimulus perhaps a million of times. By measuring the electrical conductivity of the stimulating solution before and after the reflexes it was controlled if anything else had passed into the immerging liquid in the place of the disappeared sulphuric acid. This proved to be the case for the increase of resistance of the liquid experimented with, was greater than would follow from the decrease of the sulphuric acid.

§ 2. As a thermal stimulus served immersion in cold or warm water. The most favourable result was obtained by a decreasing difference of temperature between animal and water of 10° C. and by an increasing difference of temperature of 15° C. The reservoir, isolated by an asbestos envelope, in which the immersion of the frog took place contained 50 ccm. The immersion was performed once and after that the reflex was waited for. Then it could be stated that the temperature of the water increased on an average of 8 centigrades by the immersion of the heated frog and decreased on an average of 22 centigrades by the immersion of the leg of a frog which was cooled down. Some experiments already gave a reflex before it had come to this. A sufficient quantity of reflexes large enough to avoid casualties, were accompanied by an increase of temperature of 7 centigrades resp. a decrease of temperature of 19

centigrades. Consequently at these last experiments a quantity of heat of 3,5 gr. calorie must have been withdrawn from the leg of the frog, and 9,5 calorie have been added. This heat divided itself during a reflex-time of average $7^1/_2$ sec. resp. 9 sec. over the whole immerged part of the skin. Only a very small part will have come to the benefit of the terminations of the nerves and what appears as a reflex-stimulus may very well be millions of times smaller than the total quantity of the heat which is given or taken up. The above mentioned values have again only the significance of limit values beneath which the heat resp. cold stimulus, which causes a reflex movement, must be necessarily situated.

§ 3. To produce mechanical reflex-stimuli first falling mercury drops were made use of [1]), afterwards a little ball of resin fastened to a pig's-bristle, which by an electrically moved tuning fork of 16 double vibrations was kept in a forced vibration of fixed amplitude. In both cases as much as possible the lateral side of the foot, where the corpuscula tactus are situated, was taken.

The mercury drops were all of the same size (average 100 mgr.) and were used to the number of 1 to 15, trickling down one after the other. The height from which the drops were falling varied from 1 to 20 cm. At each experiment the vis viva was calculated with which the drop came down on the skin of the animal. It was obvious that for causing a reflex the vis viva had to be in minimo 686 ergs which amount was obtained by dropping 7 drops one after the other from a falling height of 1 cm. Once it was possible to obtain a reflex by the fall of one drop from a height of 7 cm. which shows the same quantity of energy now contained in one single stimulus without any summation.

The smallest results according to vis viva which still produce a reflex were obtained with a little ball of resin of 7 milligram which vibrated with an excursion of 5 mm. After a reflextime of on an average 3 sec. the reflex movement was obtained. The quantity of energy which was added to the skin in this way in summing contains 212 ergs.

The result of the mechanical stimulation is quantitatively considerably lower than the above mentioned chemical and caloric stimulation. It leads to a minimum, which however put together in a restrict spot still possesses the peculiarity of having been communicated to a part of the skin which probably is considerably

[1]) E. A. Schäfer, Proc. Physiol. Soc. 26 Jan. 1901.

larger than the surface of a corpusculum tactus. The divergency between the quantity of energy applied and that which is used for reflex-stimulus is in this last case not by far so great as in the thermal forms of reflex stimulus. The simplest relation might be expected in the very favourable case already mentioned, in which only one drop of mercury falling from a height of 7 cm. was used. Meanwhile, with the ball of resin, still smaller values were obtained, notwithstanding the summation was taken into the account, so that we may accept, this most simple case has not at all been a most favourable one.

§ 4. The electrical stimulation brought about by discharges of a condensator which was immediately before charged with a voltage varying between 0 and 2 volts. The capacity of the condensators, which were constructed in the laboratory from mica of different thickness and coverings of tinfoil different in surface varied from $15 \times 10^{-5}$ to $4 \times 10^{-3}$ m. F. They were wholly closed in by paraffine and verified by comparing with an air-condensator. The following stimuli were used: firstly on the skin of the leg of the frog by means of little catches of steel which surround the leg: secondly on the posterior roots of the lumbal-cord, by means of platinum-electrodes set in paraffine, thirdly on the nervus vagus of a rabbit by means of platinum-electrodes set in ebonite. The stimuli were for the greater part supplied in series with an interval of $^1/_2$ sec. in a number varying between 1 and 15. All those regulations took place automatically by properly isolated swings and keys. The best results gave a condensator of $59 \times 10^{-5}$ m. F.

Skinreflexes (not ordened series)

(with condensator of 59.10—5 m.F.)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | number of stimuli |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 121 | 103 | 158 | 98 | 76 | 34 | 31 | 40 | 9 | 20 | 6 | 6 | 2 | 5 | 10 | number of observat. |
| 0.87 | 0.81 | 0.83 | 0.77 | 0.77 | 0.75 | 0.74 | 0.79 | 0.94 | 0.86 | 0.85 | 0.75 | 0.65 | 0.62 | 0.67 | average voltage |
| 22.32 | 19.35 | 20.32 | 17.49 | 17.49 | 16.59 | 16.15 | 18.41 | 26.07 | 21.81 | 21.31 | 16.59 | 12.46 | 11.34 | 13.24 | energy in 10—4 |

The above mentioned experiments were taken without a system. Observing a more judicious succession of the stimuli more favourable conditions of stimulation were obtained in the following series.

From this table it distinctly appears that the stimulus is limited to the smallest quantity of energy when a condensator 0,00035 m. F. is used. Then $1{,}4 \times 10^{-4}$ ergs is sufficient on condition that the stimulus is repeated three times with an interval of $^1/_2$ sec. Consulting the experiments about reflexes which are not mentioned

Skinreflexes (ordened series)

(the average for the different condensators).

| Capacity in m.F. | Voltage | Number of stimuli | Energy of each stimulus in $10^{-4}$ ergs. |
|---|---|---|---|
| 0.00025 | 0.40 | 2 | 2.0 |
| 0.00035 | 0.28 | 3 | 1.4 |
| 0.00059 | 0.24 | 8 | 1.7 |
| 0.0013 | 0.24 | 3 | 3.7 |
| 0.004 | 0.34 | 15 | 23.1 |

in the tables a minimum value is obtained which is only slightly larger, namely an amount of $5 \times 10^{-4}$ ergs.

The result got at the last root of the lumbal region with frogs cannot be given in one table as the individual experiments differed too much and have not been numerous enough to fix the average. In a very sensitive preparation when the above mentioned condensator of 0,00035 m. F. was used, a distinct reflex was obtained with a single discharge of only $8{,}6 \times 10^{-6}$ ergs, a result which shows clearly that in the experiments of Mr. VAN REEKUM the reflex sensitiveness has been considerably greater from the root than that from the skin. In a single case there was even found a value still-three times smaller. The above stated number however was not obtained accidentally but represents a whole series of observations (12 in number).

By central stimulation of the cervical part of the nervus vagus of a rabbit reflex-changes of the breathing were caused, which could be registered by means of the aerodromograph [1]). The said reflex consists according to the intensity of the stimulus 1. if stimulating with very weak discharges in a slight increase of frequency of breathing and in an increase of the rapidity of the current of air in in- and expiration 2. if stimulating with somewhat greater discharges, an increase of the rapidity of the stream of air notwithstanding decrease of frequency 3. stimulating with sufficient great discharges a distinct decrease in rapidity of the stream of air and frequency both. If we only examine the result mentioned in the third case as the reflex on which we want to base our measurements, the results of the experiments may be taken together as follows:

[1]) H. ZWAARDEMAKER und C. D. OUWEHAND. Arch. f. Physiol. 1901. p. 241.

Breath-reflexes.

| capacity in m.F. | 15 successive discharges | | 1 discharge | |
|---|---|---|---|---|
| | voltage | energy of the stimulus in $10^{-4}$ ergs | voltage | energy in $10^{-4}$ ergs |
| 0.00015 | 0.17 | 0.24 | 0.23 | 0.40 |
| 0.00025 | 0.13 | 0.21 | 0.21 | 0.55 |
| 0.00035 | 0.10 | 0.17 | 0.17 | 0.51 |
| 0.0059 | 0.09 | 0.24 | 0.16 | 0.76 |
| 0.0013 | 0 11 | 0.79 | 0.19 | 2.35 |
| 0.004 | 0.12 | 2.88 | 0.18 | 6.48 |

## CONCLUSION.

The reflex stimuli of different kinds used as weak as possible on cold- resp. warmblooded animals have in minimo very different value. Thus one and the same effect was brought about by applicating on the skin of a frog of an electric stimulus of $3{,}15 \times 10^{-4}$ ergs by a mechanical stimulus of 212 ergs, by a thermal stimulus of 11,5 mega-ergs and by a chemical stimulus of 57 mega-ergs. So of all these forms of stimulus the electrical is the most favourable. It may be still more favourable when we let the stimulus act not on the skin but on a posterior lumbal root of the frog. Then $3 \times 10^{6}$ ergs is sufficient to cause a typical reflex and so the amount approaches to that which occurs with weak sensorial stimuli (light stimuli vary in general between $1 \times 10^{-10}$ as lowest and $6 \times 10^{5}$ as highest value; acoustical stimuli between $0{,}3 \times 3^{-6}$ as lowest and $1 \times 10^{8}$ as highest value [1]). What holds true for frogs, as a rule holds true for mammals. From the nervus vagus there can be brought about by central stimulation with an electrical stimulus of $0{,}17 \times 10^{-4}$ ergs a very marked change of breathing, whereas a few times smaller value causes an indistinct but yet an unmistakable acceleration of breathing. Here also the minimum reflex stimuli have a limit value of the order $1 \times 10^{-6}$ ergs.

[1]) Die physiol. wahrnehmbaren Energiewanderungen, Ergebnisse der Physiologie Bd. IV. 1906. p. 423.

**(May 25, 1906).**

## ERRATA.

p 746, line 12 from top for $x = 0.01$ read $x = 0.1$
,, 13 ,, ,, ,, $x = 0.02$ ,, $x = 0.2$

# CONTENTS.

ABSORPTION and emission lines (The) of gaseous bodies. 591.

ACID (The amides of $\alpha$- and $\beta$-aminopropionic). 475.

ACIDS (On colorimetry and a colorimetric method for determining the dissociation constant of). 166.

— (Ester anhydrides of dibasic). 336.

ACRALDEHYDE (The reduction of) and some derivatives of s. divinylglycol (3.4 dihydroxy 1.5 hexadiene). 541.

ALGEBRAIC CURVES (Some properties of pencils of). 817.

ALGEBRAIC SURFACES (On pencils of). 29.

— (On the rank of the section of two). 52.

ALLYL FORMATE (On the action of ammonia and amines on). 138.

AMIDES (The) of $\alpha$- and $\beta$-aminopropionic acid. 475.

AMINES (On the action of ammonia and) on allylformate. 138.

— (On the action of ammonia and) on formic esters of glycols and glycerol. 339.

AMMONIA (On the action of) and amines on allylformate. 138.

— (On the action of) and amines on formic esters of glycols and glycerol. 339.

AMYRINE-ACETATE (The occurrence of $\beta$-) in some varieties of gutta-percha. 544.

**Anatomy**. L. BOLK: 'On the development of the cerebellum in man". 1st part. 1. 2nd part. 85.

— A. J. P. VAN DEN BROEK: "On the sympathetic nervous system in Monotremes". 91.

— D. J. HULSHOFF POL: "BOLK's centra in the cerebellum of the mammalia". 298.

— L. J. J. MUSKENS: "Anatomical research about cerebellar connections". 563.

— L. BOLK: "On the relation between the teeth-formulas of the platyrrhine and catarrhine primates". 781.

APOGAMY (On a case of) observed with Dasylirion acrotrichum Zucc. 684.

**Astronomy**. J. WEEDER: "Approximate formulae of a high degree of accuracy for the ratio of the triangles in the determination of an elliptic orbit from three observations." II. 104.

— J. A. C. OUDEMANS: "Supplement to the account of the determination of the longitude of St. Denis (Island of Reunion), executed in 1874, containing also a general account of the observation of the transit of Venus". 110.

— H. G. VAN DE SANDE BAKHUYZEN: "Preliminary Report on the Dutch expedition to Burgos for the observation of the total solar eclipse of August 30, 1905". 501.

**Astronomy.** H. J. ZWIERS: "Researches on the orbit of the periodic comet HOLMES and on the perturbations of its elleptic motion". 642.

— J. C. KAPTEYN: "On the parallax of the nebulae". 691.

— W. DE SITTER: "On the orbital planes of Jupiter's satellites". 767.

ATOMS (The introduction of halogen) into the benzene core in the reduction of aromatic nitro-compounds. 680.

AZOBENZENE, Stilbene and Dibenzyl (On Diphenylhydrazine, Hydrazobenzene and Benzylaniline, and on the miscibility of the last two with) in the solid aggregate condition. 466.

BACTERIA (Methan as carbon-food and source of energy for). 327.

BAKHUIS ROOZEBOOM (H. W.). The different branches of the three-phaselines for solid, liquid, vapour in binary systems in which a compound occurs. 455.

— presents a paper of Dr. F. M. JAEGER: "On Diphenylhydrazine, Hydrazobenzene and Benzylaniline, and on the miscibility of the last two with Azobenzene, Stilbene and Dibenzyl in the solid aggregate condition". 466.

— The boiling points of saturated solutions in binary systems in which a compound occurs. 536.

— presents a paper of Dr. A. SMITS: "On the hidden equilibria in the $p$, $x$-sections below the eutectic point." 568.

— presents a paper of Dr. A. SMITS: "On the phenomena which occur when the plaitpoint curve meets the three phase line of a dissociating binary compound". 571.

— presents a paper of J. J. VAN LAAR: "On the course of melting-point curves for compounds which are partially dissociated in the liquid phase, the proportion of the products of dissociation being arbitrary". 699.

— and J. OLIE JR. The solubilities of the isomeric chromic chlorides. 66.

BAKHUYSEN (H. G. VAN DE SANDE). v. SANDE BAKHUYSEN (H. G. VAN DE).

BAROMETRIC HEIGHTS (On frequency curves of). 549.

BENZENE CORE (The introduction of halogen atoms into the) in the reduction of aromatic nitro-compounds. 680.

BENZYLANILINE (On Diphenylhydrazine, Hydrazobenzene and), and on the miscibility of the last two with Azobenzene, Stilbene and Dibenzyl in the solid aggregate condition. 466.

BESSEL FUNCTIONS (The quotient of two successive). I. 547. II. 640.

BEIJERINCK (M. W.) presents a paper of N. L. SÖHNGEN: "Methan as carbon-food and source of energy for bacteria". 327.

BINARY COMPOUND (On the phenomena which occur when the plaitpoint curve meets the three phase line of a dissociating). 571.

BINARY MIXTURE (The molecular rise of the lower critical temperature of a) of normal components. 144.

— (The properties of the sections of the surface of saturation of a) on the side of the components. 280.

BINARY MIXTURES (On the course of the spinodal and the plaitpoint lines for) of normal substances. 3rd communication. 578.

BINARY SYSTEM (On the hidden equilibria in the $p, x$-diagram of a) in consequence of the appearance of solid substances. 196.

BINARY SYSTEMS (The different branches of the three-phaselines for solid, liquid, vapour in) in which a compound occurs. 455.

— (The boiling points of saturated solutions in) in which a compound occurs. 536.

BLAAUW (A. H.) and F. A. F. C. WENT. On a case of apogamy with Dasylirion acrotrichum Zucc. 684.

BLANKSMA (J. J.). Nitration of symmetric nitrometaxylene. 70.

— The introduction of halogen atoms into the benzene core in the reduction of aromatic nitro-compounds. 680.

— and F. M. JAEGER. On the six isomeric tribromoxylenes. 153.

BLOOD (On catalases of the). 623.

BOCKWINCKEL (H. B. A.). On the propagation of light in a biaxial crystal around a centre of vibration. 728.

BOILING POINTS (The) of saturated solutions in binary systems in which a compound occurs. 536.

BOLK's CENTRA in the cerebellum of the mammalia. 298.

BOLK (L.). On the development of the cerebellum in man. 1st part. 1. 2nd part. 85.

— presents a paper of Dr. A. J. P. VAN DEN BROEK: "On the sympathetic nervous system in Monotremes". 91.

— On the relation between the teeth-formulas of the platyrrhine and catharrine primates. 781.

BOLTZMANN's Vorlesungen über Gastheorie (Some remarks on the quantity $H$ in). 630.

**Botany.** E. VERSCHAFFELT: "Some observations on the longitudinal growth of stems and flower-stalks". 8.

— F. A. F. C. WENT: "Some remarks on the work of Dr. A. A. PULLE: "An enumeration of the vascular plants known from Surinam, together with their distribution and synonymy". 639.

— F. A. F. C. WENT and A. H. BLAAUW: "On a case of apogamy observed with Dasylirion acrotrichum Zucc." 684.

— W. BURCK: "On plants which in the natural state have the character of eversporting varieties in the sense of the mutation theory". 798.

BOUMAN (Z. P.). An article on the knowledge of the tetrahedral complex. 358.

BROEK (A. J. P. VAN DEN). On the sympathetic nervous system in Monotremes. 91.

BROMINATION (The) of toluene. 512.

BROMINE and iodine (Contribution to the knowledge of the isomorphous substitution of the elements fluorine, chlorine,) in organic molecules. 614.

BURCK (W.). On plants which in the natural state have the character of eversporting varieties in the sense of the mutation theory. 798.

CARBON-FOOD (Methan as) and source of energy for bacteria. 327.

CARDINAAL (J.) presents a paper of Dr. H. DE VRIES: "Central projection in the space of LOBATSCHEFSKY". 1st part. 389.

CATALASES (On) of the blood. 623.

CAUCHY'S THEORY (Derivation of the fundamental equations of metallic reflection from). 486.

CENTRAL PROJECTION in the space of LOBATSCHEFSKY. 1st part. 389.

CEREBELLAR connections (Anatomical research about). 563.

CEREBELLUM in man (On the development of the). 1st part. 1. 2nd part. 85.

— of the mammalia (BOLK's centra in the). 298.

**Chemistry.** J. J. VAN LAAR: "On the shape of the plaitpoint curves for mixtures of normal substances". 2nd communication. 33.

— H. W. BAKHUIS ROOZEBOOM and J. OLIE JR: "The solubilities of the isomeric chromic chlorides". 66.

— J. J. BLANKSMA: "Nitration of symmetric nitrometaxylene". 70.

— F. M. JAEGER: "On some derivatives of phenylcarbamic acid". 127.

— P. VAN ROMBURGH: "On the presence of lupeol in some kinds of gutta-percha". 137.

— P. VAN ROMBURGH: "On the action of ammonia and amines on allyl formate". 138.

— A. J. ULTEE: "On the action of hydrocyanic acid on ketones". 141.

— J. J. VAN LAAR: "The molecular rise of the lower critical temperature of a binary mixture of normal components". 144.

— F. M. JAEGER and J. J. BLANKSMA: "On the six isomeric tribromoxylenes". 153.

— F. H. EYDMAN JR: "On colorimetry and a colorimetric method for determining the dissociation constant of acids". 166.

— D. MOL: "Ester anhydrides of dibasic acids". 336.

— L. VAN ITALLIE: "Thalictrum aquilegifolium, a hydrogen cyanide-yielding plant". 337.

— P. VAN ROMBURGH: "On the action of ammonia and amines on formic esters of glycols and glycerol". II. 339.

— W. A. VAN DORP and G. C. A. VAN DORP: "On the chlorides of maleic acid and of fumaric acid and on some of their derivatives". 387.

— H. W. BAKHUIS ROOZEBOOM: "The different branches of the three-phaselines for solid, liquid, vapour in binary systems in which a compound occurs". 455.

— A. P. N. FRANCHIMONT and H. FRIEDMANN: "The amides of $\alpha$- and $\beta$-amino-propionic acid". 475.

— A. F. HOLLEMAN and F. H. VAN DER LAAN: "The bromination of toluene". 512.

— H. W. BAKHUIS ROOZEBOOM: "The boiling points of saturated solutions in binary systems in which a compound occurs". 536.

— P. VAN ROMBURGH and W. VAN DORSSEN: "The reduction of acraldehyde and some derivatives of *s.* divinylglycol (2.4 dihydroxy 1.5 hexadiene). 541.

— P. VAN ROMBURGH and N. H. COHEN: "The occurrence of $\beta$-amyrineacetate in some varieties of gutta-percha". 544.

— P. VAN ROMBURGH and W. VAN DORSSEN: "On the simplest hydrocarbon with two conjugated systems of double bonds, 1. 3. 5. hexatriene". 565.

— A. SMITS: "On the hidden equilibria in the $p, x$-sections below the eutectic point". 568.

— A. SMITS: "On the phenomena which occur when the plaitpoint curve meets the three phaseline of a dissociating binary compound". 571.

**Chemistry.** J. J. VAN LAAR: "On the course of the spinodal and the plaitpoint lines for binary mixtures of normal substances". 3rd communication. 578.

— A. F. HOLLEMAN: "On the nitration of ortho- and metadibromobenzene". 678.

— J. J. BLANKSMA: "The introduction of halogen atoms into the benzene core in the reduction of aromatic nitro-compounds". 680.

— J. J. VAN LAAR: "On the course of melting-point curves for compounds which are partially dissociated in the liquid phase, the proportion of the products of dissociating being arbitrary". 699.

— C. J. ENKLAAR: "On Ocimene and Myrcene, a contribution to the knowledge of the aliphatic terpenes". 714.

— C. J. ENKLAAR: "On some aliphatic terpene alcohols". 723.

CHLORIDES (The solubilities of the isomeric chromic). 66.

— (On the) of maleic acid and of fumaric acid and on some of their derivatives. 387.

CHLORINE, bromine and iodine (Contribution to the knowledge of the isomorphous substitution of the elements fluorine). 614.

CLIMATE (Oscillations of the solar activity and the). 2nd communication. 155.

CLOCKS (HUYGENS' sympathic) and related phenomena in connection with the principal and the compound oscillations presenting themselves when two pendulums are suspended to a mechanism with one degree of freedom. 436.

COHEN (N. H.) and P. VAN ROMBURGH. The occurrence of β-amyrine acetate in some varieties of gutta percha. 544.

COLORIMETRY (On) and a colorimetric method for determining the dissociation constant of acids. 166.

COMET HOLMES (Researches on the orbit of the periodic) and on the perturbations of its elliptic motion. 642.

COMPLEX (An article on the knowledge of the tetrahedral). 358.

COMPLEXES of rays (A group of) whose singular surface consists of a scroll and a number of planes. 662.

COMPONENTS (The molecular rise of the lower critical temperature of à binary mixture of normal). 144.

— (Properties of the critical line (plaitpoint line) on the side of the). 271.

— (The properties of the sections of the surface of saturation of a binary mixture on the side of the). 280.

— (The exact numerical values for the properties of the plaitpoint line on the side of the). 289.

— (On the possibility of predicting the properties of mixtures from those of the). 743.

COMPOUNDS (On the course of meltingpoint curves for) which are partially dissociated in the liquid phase, the proportion of the products of dissociation being arbitrary. 699.

CONDUCTIBILITY of heat in crystals (A simple geometrical deduction of the relations existing between known and unknown quantities, mentioned in the method of VOIGT for determining the). 793.

CORALLIUM from Timor (On a new species of). 268.

CORONA (Measurement of the heat produced by the integral radiation of the) and of the solar disk. 503.

CORTI'S ORGAN (On the pressure of sound in). 60.

CRANIUM (The primordial) of Tarsius spectrum. 397.

CREATININ (On the excretion of) in man. 363.

CRITICAL LINE (plaitpoint line) (Properties of the) on the side of the components. 271.

CRYOGENIC LABORATORY (Methods and apparatus used in the). VII. 77. VIII 79. IX. 82.

CRYOSTAT (A modified). 77.

— with liquid oxygen for temperatures below — 210°C. 79.

CRYSTAL (On the propagation of light in a biaxial) around a centre of vibration. 728.

**Crystallography.** F. M. JAEGER: "On Diphenylhydrazine, Hydrazobenzene and Benzylaniline, and on the miscibility of the last two with Azobenzene, Stilbene and Dibenzyl in the solid aggregate condition". 466.

— F. M. JAEGER: "Contribution to the knowledge of the isomorphous substitution of the elements fluorine, chlorine, bromine and iodine, in organic molecules". 614.

CRYSTALS (A simple geometrical deduction of the relations existing between known and unknown quantities, mentioned in the method of VOIGT for determining the conductibility of heat in). 793.

CURVE (The PLÜCKER equivalents of a cyclic point of a twisted). 498.

CYCLIC POINT (The PLÜCKER equivalents of a) of a twisted curve. 498.

DASYLIRION ACROTRICHUM ZUCC. (On a case of apogamy observed with). 684.

DEPOSITS (On brackish and fresh water) of the river Silat in Western-Borneo. 742.

DIBENZYL (On Diphenylhydrazine, Hydrazobenzene and Benzylaniline, and on the miscibility of the last two with Azobenzene, Stilbene and) in the solid aggregate condition. 466.

DILUVIUM of Holland (The geographical and geological signification of the Hondsrug, and the examination of the erratics in the northern). 427.

— of the Netherlands North of the Rhine (On fragments of rocks from the Ardennes found in the). 518.

DIPHENYLHYDRAZINE (On), Hydrazobenzene and Benzylaniline, and on the miscibility of the last two with Azobenzene, Stilbene and Dibenzyl in the solid aggregate condition. 466.

DISSOCIATION CONSTANT of acids (On colorimetry and a colorimetric method for determining the). 166.

DIVINYLGLYCOL (The reduction of acraldehyde and some derivatives of s.) (3.4 dihydroxy 1.5 hexadiene). 541,

DORP (W. A. and G. C. A. VAN). On the chlorides of maleic acid and of fumaric acid and on some of their derivatives. 387.

DORSSEN (W. VAN) and P. VAN ROMBURGH. The reduction of acraldehyde and some derivatives of s. divinylglycol (3.4 dihydroxy 1.5 hexadiene). 541.

— On the simplest hydrocarbon with two conjugated systems of double bonds 1.3.5 hexatriene. 565.

DUBOIS (EUG.). The geographical and geological signification of the Hondsrug, and the examination of the erratics in the Northern diluvium of Holland. 427.

DYNAMICS of the electron (Remarks concerning the). 477.

EASTON (C.). Oscillations of the solar activity and the climate. 2nd communication. 155,

EINTHOVEN (W.). Analysis of the curves obtained with the string galvanometer. Mass and tension of the quartz wire and resistance to the motion of the string. 210.

ELECTRON (Remarks concerning the dynamics of the). 477.

ELLIPTIC MOTION (Researches on the orbit of the periodic comet HOLMES and on the perturbations of its). 642.

ELLIPTIC ORBIT (Approximate formulae of a high degree of accuracy for the ratio of the triangles in the determination of an) from three observations. II. 104.

EMISSION LINES (The absorption and) of gaseous bodies. 591.

ENKLAAR (C. J.). On Ocimene and Myrcene, a contribution to the knowledge of the aliphatic terpenes. 714.

— On some aliphatic terpene alcohols. 723.

EQUATIONS (Derivation of fundamental) of metallic reflection from CAUCHY's theory. 486.

EQUILIBRIA (The *Tx*-) of solid and fluid phases for variable values of the pressure. 193.

— (On the hidden) in the *px*-diagram of a binary system in consequence of the appearance of solid substances. 196.

— (On the hidden) in the *p*,*x*-sections below the eutectic point. 568.

ERINACEUS EUROPAEUS L. (The uterus of) after parturition. 812.

ERRATICS (The geographical and geological signification of the Houdsrug, and the examination of the) in the Northern Diluvium of Holland. 427.

ERRATUM. 426.

ESTER ANHYDRIDES of dibasic acids. 336.

ESTERS (On the action of ammonia and amines on formic) of glycols and glycerol. 339.

EUTECTIC POINT (On the hidden equilibria in the *p*,*x*-sections below the). 568.

EYDMAN JR. (F. H.). On colorimetry and a colorimetric method for determining the dissociation constant of acids. 166.

EXCRETION (On the) of creatinin in man. 363.

FISCHER (EUGEN). On the primordial cranium of Tarsius spectrum. 397.

FLOWER-STALKS (Some observations on the longitudinal growth of stems and). 8.

FLUIDS of the body (On the differentiation of), containing proteid. 628.

FLUORINE, chlorine, bromine and iodine (Contribution to the knowledge of the isomorphous substitution of the elements), in organic molecules. 614.

FRANCHIMONT (A. P. N.). presents a paper of Dr. D. MOL: "Ester anhydrides of dibasic acids." 336.

— presents a paper of Dr. F. M. JAEGER: "Contribution to the knowledge of the isomorphous substitution of the elements fluorine, chlorine, bromine and iodine, in organic molecules." 614.

— and H. FRIEDMANN. The amides of $\alpha$- and $\beta$-aminopropionic acid. 475.

FREQUENCY CURVES (On) of meteorological elements. 314.

— (On) of barometric heights. 549.

FRIEDMANN (H.) and A. P. N. FRANCHIMONT. The amides of $\alpha$- and $\beta$-aminopropionic acid. 475.

FUMARIC ACID (On the chlorides of maleic acid and of) and on some of their derivatives. 387.

FUNCTIONS (The quotient of two successive BESSEL). I. 547. II. 640.

GALVANOMETER (Analysis of the curves obtained with the string). Mass and tension of the quartz wire and resistance to the motion of the string. 210.

GAS (Improvement to the open mercury manometer of reduced height with transference of pressure by means of compressed). 75.

— (Improvement in the transference of pressure by compressed) especially for the determination of isothermals. 76.

GASEOUS BODIES (The absorption and emission lines of). 591.

GASES (The purifying of) by cooling combined with compression especially the preparing of pure hydrogen. 82.

GASPHASE (Contribution to the knowledge of the $px$- and the $pT$-lines for the case that two substances enter into a combination which is dissociated in the liquid and the). 200.

GASTHEORIE (Some remarks on the quantity $H$ in BOLTZMANN's Vorlesungen über). 630.

**Geology.** H. G. JONKER: "Some observations on the geological structure and origin of the Hondsrug". 96.

— EUG. DUBOIS: "The geographical and geological signification of the Hondsrug, and the examination of the erratics in the Northern Diluvium of Holland". 427.

— C. E. A. WICHMANN: "On fragments of rocks from the Ardennes found in the diluvium of the Netherlands North of the Rhine". 518.

— K. MARTIN: "On brackish and fresh water deposits of the river Silat in Western-Borneo." 742.

GLYCOLS and glycerol (On the action of ammonia and amines on formic esters of). 339.

GROWTH of stems and flower-stalks (Some observations on the longitudinal). 8.

GUTTA-PERCHA (On the presence of lupeol in some kinds of). 137.

— The occurrence of β-amyrine acetate in some varieties of). 544.

HAGA (H.) presents a paper of Dr. C. SCHOUTE: "Determination of the Thomson-effect in mercury". 331.

HAMBURGER (H. J.). A method for determining the osmotic pressure of very small quantities of liquid. 394.

HEAT (On the radiation of) in a system of bodies having a uniform temperature. 401.

— (Measurement of the) produced by the integral radiation of the corona and of the solar disk. 503.

— in crystals (A simple geometrical deduction of the relations existing between known and unknown quantities, mentioned in the method of VOIGT for determining the conductibility of). 793.

HEXATRIENE (On the simplest hydrocarbon with two conjugated systems of double bonds, 1, 3, 5). 565.

HICKSON (SYDNEY J.). On a new species of Corallium from Timor. 268.

HOEK (P. P. C.). On the polyandry of Scalpellum Stearnsi. 659.

HOLLEMAN (A. F.) presents a paper of Dr. J. J. BLANKSMA: "Nitration of symmetric nitrometaxylene." 70.

— presents a paper of Dr. F. M. JAEGER and Dr. J. J. BLANKSMA: "On the six isomeric tribromoxylenes." 153.

HOLLEMAN (A. F.). On the nitration of ortho- and metadibromobenzene. 678.
— presents a paper of Dr. J. J. BLANKSMA: "The introduction of halogen atoms into the benzene core in the reduction of aromatic nitro-compounds." 680.
— and F. H. VAN DER LAAN. The bromination of toluene. 512.
HOLMES (Researches on the orbit of the periodic comet) and on the perturbations of its elliptic motion. 642.
HONDSRUG (Some observations on the geological structure and origin of the). 96.
— (The geographical and geological signification of the), and the examination of the erratics in the Northern Diluvium of Holland. 427.
HOOGEWERFF (S.) presents a paper of F. H. EYDMAN JR.: "On colorimetry and a colorimetric method for determining the dissociation constant of acids." 166.
HUBRECHT (A. A. W.) presents a paper of Prof. EUGEN FISCHER: "On the primordial cranium of Tarsius spectrum." 397.
— presents a paper of Prof. H. STRAHL: "The uterus of Erinaceus europaeus L. after parturition." 812.
HULSHOFF POL (D. J.). BOLK's centra in the cerebellum of the mammalia. 298.
HUYGENS' sympathic clocks and related phenomena in connection with the principal and the compound oscillations presenting themselves when two pendulums are suspended to a mechanism with one degree of freedom. 436.
HYDRAZOBENZENE (On Diphenylhydrazine), and Benzylaniline, and on the miscibility of the last two with Azobenzene, Stilbene and Dibenzyl in the solid aggregate condition. 466.
HYDROCARBON (On the simplest) with two conjugated systems of double bonds 1, 3, 5 hexatriene. 565.
HYDROCYANIC ACID (On the action of) on ketones. 141.
HYDROGEN (The purifying of gases by cooling combined with compression, especially the preparing of pure). 82.
HYDROGEN CYANIDE-yielding-plant (Thalictrum aquilegifolium, a). 337.
ICE (On the motion of a metal wire through a lump of). 653.
INTEGRAL of KUMMER (A definite). 350.
INTENSITIES of tones (On the ability of distinguishing). 421.
IODINE (Contribution to the knowledge of the isomorphous substitution of the elements fluorine, chlorine, bromine and) in organic molecules. 614.
ISOMORPHOUS SUBSTITUTION (Contribution to the knowledge of the) of the elements fluorine, chlorine, bromine and iodine, in organic molecules. 614.
ISOTHERMALS (Improvement in the transference of pressure by compressed gas especially for the determination of). 76.
ITALLIE (L. VAN). Thalictrum aquilegifolium, a hydrogen cyanide-yielding plant. 337.
— On catalases of the blood. 623.
— On the differentiation of fluids of the body, containing proteid. 628.
JAEGER (F. M.). On some derivatives of Phenylcarbamic acid. 127.
— On Diphenylhydrazine, Hydrazobenzene and Benzylaniline, and on the miscibility of the last two with Azobenzene, Stilbene and Dibenzyl in the solid aggregate condition. 466.

JAEGER (F. M.). Contributions to the knowledge of the isomorphous substitution of the elements fluorine, chlorine, bromine and iodine in organic molecules. 614.

— A simple geometrical deduction of the relations existing between known and unknown quantities, mentioned in the method of VOIGT for determining the conductibility of heat in crystals. 793.

— and J. J. BLANKSMA. On the six isomeric tribromoxylenes. 153.

JONKER (H. G.). Some observations on the geological structure and origin of the Hondsrug. 96.

JULIUS (W. H.). Measurement of the heat produced by the integral radiation of the corona and of the solar disk. 503.

— A new method for determining the rate of decrease of the radiating power from the center toward the limb of the solar disk. 668.

JUPITER's satellites (On the orbital planes of). 767.

KAMERLINGH ONNES (H.). Improvement to the open mercury manometer of reduced height with transference of pressure by means of compressed gas. 75.

— Improvement in the transference of pressure by compressed gas especially for the determination of isothermals. 76.

— Methods and apparatus used in the cryogenic laboratory. VII. A modified cryostat. 77. VIII. Cryostat with liquid oxygen for temperatures below —210° C. 79. IX. The purifying of gases by cooling combined with compression, especially the preparing of pure hydrogen. 82.

— presents a paper of Dr. J. E. VERSCHAFFELT: "Contributions to the knowledge of VAN DER WAALS' $\psi$-surface. X. On the possibility of predicting the properties of mixtures from those of the components". 743.

— presents a paper of Dr. J. E. VERSCHAFFELT: "Appendix to the communications published in the meetings of June 28, September 27, 1902 and October 31, 1903". 752.

KAPTEYN (J. C.). On the parallax of the nebulae. 691.

— presents a paper of Dr. W. DE SITTER: "On the orbital planes of Jupiter's satellites". 767.

KAPTEYN (W.). A definite integral of KUMMER. 350.

— The quotient of two successive BESSEL functions. I. 547. II. 640.

KETONES (On the action of hydrocyanic acid on). 141.

KLUYVER (J. C.). A local probability problem. 341.

KOHNSTAMM (PH.) — Some remarks on Dr.— last papers (on the osmotic pressure). 49.

KORTEWEG (D. J.) presents a paper of Dr. W. A. VERSLUYS: "On the number of common tangents of a curve and a surface". 176.

— HUYGENS' sympathic clocks and related phenomena in connection with the principal and the compound oscillations presenting themselves when two pendulums are suspended to a mechanism with one degree of freedom. 436.

KUMMER (A definite integral of). 350.

LAAN (F. H. VAN DER) and A. F. HOLLEMAN. The bomination of toluene. 512.

LAAR (J. J. VAN). On the shape of the plaitpoint curves for mixtures of normal substances. 2nd communication. 33.

LAAR (J. J. VAN). Some remarks on Dr. PH. KOHNSTAMM's last papers. 49.

— The molecular rise of the lower critical temperature of a binary mixture of normal components. 144.

— On the course of the spinodal and the plaitpoint lines for binary mixtures of normal substances. 3rd communication. 578.

— On the course of melting-point curves for compounds which are partially dissociated in the liquid phase, the proportion of the products of dissociation being arbitrary. 699.

LIGHT (On the theory of reflection of) by imperfectly transparent bodies. 377.

— (On the propagation of) in a biaxial crystal around a centre of vibration. 728.

LINES (Contribution to the knowledge of the $px$- and $pT$-) for the case that two substances enter into a combination which is dissociated in the liquid and the gasphase. 200.

LIQUID (A method for determining the osmotic pressure of very small quantities of). 394.

— and the gasphase (Contribution to the knowledge of the $px$- and the $pT$-lines for the case that two substances enter into a combination which is dissociated in the). 200.

LIQUID PHASE (On the course of melting-point curves for compounds which are partially dissociated in the) the proportion of the products of dissociation being arbitrary. 699.

LOBATSCHEFSKY (Central projection in the space of). 1st part. 389.

LONGITUDE of St. Denis (Island of Réunion) (Supplement to the account of the determination of the), executed in 1874, containing also a general account of the observation of the transit of Venus. 110.

LORENTZ (H. A.) presents a paper of J. J. VAN LAAR: "On the shape of the plaitpoint curves for mixtures of normal substances". 2nd communication. 33.

— presents a paper of J. J. VAN LAAR: "Some remarks on Dr. PH. KOHNSTAMM's last papers". 49.

— presents a paper of J. J. VAN LAAR: "The molecular rise of the lower critical temperature of a binary mixture of normal components". 144.

— presents a paper of Prof. R. SISSINGH: "On the theory of reflection of light by imperfectly transparent bodies". 377.

— On the radiation of heat in a system of bodies having a uniform temperature. 401.

— presents a paper of Prof. R. SISSINGH: "Derivation of the fundamental equations of metallic reflection from CAUCHY's theory". 486.

— presents a paper of J. J. VAN LAAR: "On the course of the spinodal and the plaitpoint lines for binary mixtures of normal substances. (3rd communication). 578.

— The absorption and emission lines of gaseous bodies. 591.

— presents a paper of O. POSTMA; "Some remarks on the quantity $H$ in BOLTZMANN's: Vorlesungen über Gastheorie". 630.

— presents a paper of L. S. ORNSTEIN: "On the motion of a metal wire through a lump of ice". 653.

— presents a paper of H. B. A. BOCKWINKEL: "On the propagation of light in a biaxial crystal around a centre of vibration". 728.

LUPEOL (On the presence of) in some kinds of gutta percha. 137.

MAGNETIC FORCE (Magnetic resolution of spectral lines and). 1st part. 814.

MALEIC ACID (On the chlorides of) and of fumaric acid and on some of their derivatives. 387.

MAMMALIA (BOLK's centra in the cerebellum of the). 298.

MAN (On the development of the cerebellum in). 1st part. 1. 2nd part. 85.

— (On the excretion of creatinin in). 363.

MANOMETER (Improvement to the open mercury) of reduced height with transference of pressure by means of compressed gas. 75.

MARTIN (K.) presents a paper of Dr. H. G. JONKER: "Some observations on the geological structure and origin of the Hondsrug." 96.

— presents a paper of Prof. EUG. DUBOIS: "The geographical and geological signification of the Hondsrug, and the examination of the erratics in the Northern Diluvium of Holland." 427.

— On brackish and fresh water deposits of the river Silat in Western-Borneo. 742.

**Mathematics.** JAN DE VRIES: "On pencils of algebraic surfaces." 29.

— W. A. VERSLUYS: "On the rank of the section of two algebraic surfaces." 52.

— W. A. VERSLUYS: "On the number of common tangents of a curve and a surface." 176.

— J. C. KLUYVER: "A local probability problem." 341.

— W. KAPTEYN: "A definite integral of KUMMER." 350.

— Z. P. BOUMAN: "An article on the knowledge of the tetrahedral complex." 358.

— H. DE VRIES: "Central projection in the space of Lobatschefsky." (1st part). 389.

— D. J. KORTEWEG: "HUYGENS' sympathic clocks and related phenomena in connection with the principal and the compound oscillations presenting themselves when two pendulums are suspended to a mechanism with one degree of freedom." 436.

— P. H. SCHOUTE: "A tortuous surface of order six and of genus zero in space $Sp_4$ of four dimensions." 489.

— W. A. VERSLUYS: "The PLÜCKER equivalents of a cyclic point of a twisted curve." 498.

— W. KAPTEYN: "The quotient of two successive Bessel functions." I. 547. II. 640.

— JAN DE VRIES: "A group of complexes of rays whose singular surface consists of a scroll and a number of planes." 662.

— P. H. SCHOUTE: "A particular series of quadratic surfaces with eight common points and eight common tangential planes." 754.

— JAN DE VRIES: "Some properties of pencils of algebraic curves." 817.

MELTING POINT CURVES (On the course of) for compounds which are partially dissociated in the liquid phase, the proportion of the products of dissociation being arbitrary. 699.

MERCURY (Determination of the Thomson-effect in). 331.

METADIBROMOBENZENE (On the nitration of ortho-and). 678.

METAL WIRE (On the motion of a) through a lump of ice. 653.

**Meteorology.** C. EASTON: "Oscillations of the solar activity and the climate". 2nd communication. 155.

— J. P. VAN DER STOK: "On frequency curves of meteorological elements". 314.

— J. P. VAN DER STOK: "On frequency curves of barometric heights". 549.

METHAN as carbon-food and source of energy for bacteria. 327.

METHOD (A) for determining the osmotic pressure of very small quantities of liquid. 394.

METHOD of VOIGT (A simple geometrical deduction of the relations existing between known and unknown quantities, mentioned in the) for determining the conductibility of heat in crystals. 793.

METHODS and apparatus used in the Cryogenic Laboratory. VII. A modified Cryostat. 77. VIII. Cryostat with liquid oxygen for temperatures below — 210° C. 79. IX. The purifying of gases by cooling combined with compression, especially the preparing of pure hydrogen. 83.

**Microbiology.** N. L. SÖHNGEN: "Methan as carbon-food and source of energy for bacteria". 327.

MIXTURES (On the possibility of predicting the properties of) from those of the components. 743.

MIXTURES of normal substances (On the shape of the plaitpoint curves for). 2nd communication. 33.

MOL (D.). Ester anhydrides of dibasic acids. 336.

MOLECULAR RISE (The) of the lower critical temperature of a binary mixture of normal components. 144.

MOLL (J. W.) presents a paper of Dr. W. BURCK: "On plants which in the natural state have the character of eversporting varieties in the sense of the mutation theory". 798.

MONOTREMES (On the sympathetic nervous system in). 91.

MUSKENS (L. J. J.). Anatomical research about cerebellar connections. 563.

MUTATION THEORY (On plants which in the natural state have the character of eversporting varieties in the sense of the). 798.

MYRCENE (On Ocimene and), a contribution to the knowledge of the aliphatic terpenes. 714.

NEBULAE (On the parallax of the). 691.

NERVOUS SYSTEM (On the sympathetic) in Monotremes. 91.

NITRATION (On the) of ortho- and metadibromobenzene. 678.

— of symmetric nitrometaxylene. 70.

NITRO-COMPOUNDS (The introduction of halogen atoms into the benzene core in the reduction of aromatic). 680.

NITROMETAXYLENE (Nitration of symmetric). 70.

NYLAND (A. A.). The prismatic camera. 505.

OCIMENE (On) and Myrcene, a contribution to the knowledge of the aliphatic terpenes. 714.

OLIE JR. (J.) and H. W. BAKHUIS ROOZEBOOM. The solubilities of the isomeric chromic chlorides. 66.

ONNES (H. KAMERLINGH). v. KAMERLINGH ONNES (H.).

ORBIT of the periodic comet HOLMES (Researches on the) and on the perturbations of its elliptic motion. 642.

ORNSTEIN (L. S.). On the motion of a metal wire through a lump of ice. 653.

ORTHO- and metadibromobenzene (On the nitration of). 678.

OSCILLATIONS (HUYGENS' sympathic clocks and related phenomena in connection with the principal and the compound) presenting themselves when two pendulums are suspended to a mechanism with one degree of freedom. 436.

ORBIT of the periodic comet HOLMES (Researches on the) and on the perturbations of its elliptic motion. 642.

ORBITAL PLANES (On the) of Jupiter's satellites. 767.

OSMOTIC PRESSURE (Some remarks on Dr. PH. KOHNSTAMM's last papers on the). 49.

— (A method for determining the) of very small quantities of liquid. 394.

OUDEMANS (J. A. C.). Supplement to the account of the determination of the longitude of St. Denis (Island of Réunion), executed in 1874, containing also a general account of the observation of the transit of Venus. 110.

PARALLAX (On the) of the nebulae. 691.

PEKELHARING (C. A.). On the excretion of creatinin in man. 363.

— presents a paper of DR. L. VAN ITALLIE: "On catalases of the blood." 623.

— presents a paper of DR. L. VAN ITALLIE: "On the differentiation of fluids of the body, containing proteid." 628.

PENCILS (On) of algebraic surfaces. 29.

— (Some properties of) of algebraic curves. 817.

PHASE LINE (On the phenomena which occur when the plaitpoint curve meets the three) of a dissociating binary compound. 571.

PHASE LINES (The different branches of the three-) for solid, liquid, vapour in binary systems in which a compound occurs. 455.

PHASE PRESSURE (The shape of the sections of the surface of saturation normal to the $x$ axis, in case of a three) between two temperatures. 184.

PHASES (The $Tx$-equilibria of solid and fluid) for variable values of the pressure. 193.

PHENYLCARBAMIC ACID (On some derivatives of). 127.

Physics. J. J. VAN LAAR: "Some remarks on Dr. PH. KOHNSTAMM's last papers". 49.

— H. KAMERLINGH ONNES: "Improvement to the open mercury manometer of reduced height with transference of pressure by means of compressed gas" 75.

— H. KAMERLINGH ONNES: "Improvement in the transference of pressure by compressed gas especially for the determination of isothermals". 76.

— H. KAMERLINGH ONNES: "Methods and apparatus used in the cryogenic laboratory. VII. A modified cryostat. 77. VIII. Cryostat with liquid oxygen for temperatures below — 210° C. 79. IX. The purifying of gases by cooling combined with compression, especially the preparing of pure hydrogen". 82.

— J. D. VAN DER WAALS: "The shape of the sections of the surface of saturation normal to the $x$-axis, in case of a three phase pressure between two temperatures". 184.

— J. D. VAN DER WAALS: "The $T,x$- equilibria of solid and fluid phases for variable values of the pressure". 193.

— A. SMITS: "On the hidden equilibria in the $p,x$- diagram of a binary system in consequence of the appearance of solid substances". 196.

— A. SMITS: "Contribution to the knowledge of the $p.x$- and the $pT$- lines for the case that two substances enter into a combination which is dissociated in the liquid and the gasphase". 200.

**Physics.** J. D. VAN DER WAALS: "Properties of the critical line (plaitpoint line) on the side of the components." 271.

— J. D. VAN DER WAALS: "The properties of the sections of the surface of saturation of a binary mixture on the side of the components." 280.

— J. D. VAN DER WAALS: "The exact numerical values for the properties of the plaitpoint line on the side of the components." 289.

— C. SCHOUTE: "Determination of the Thomson-effect in mercury". 331.

— R. SISSINGH: " On the theory of reflection of light by imperfectly transparent bodies". 377.

— H. A. LORENTZ: "On the radiation of heat in a system of bodies having a uniform temperature". 401.

— J. D. VAN DER WAALS JR.: "Remarks concerning the dynamics of the electron". 477.

— R. SISSINGH: "Derivation of the fundamental equations of metallic reflection from CAUCHY's theory". 486.

— H. A. LORENTZ: "The absorption and emission lines of gaseous bodies". 591.

— O. POSTMA: "Some remarks on the quantity $H$ in BOLTMANN's "Vorlesungen über Gastheorie." " 630.

— L. S. ORNSTEIN: "On the motion of a metal wire through a lump of ice". 653.

— W. H. JULIUS: "A new method for determining the rate of decrease of the radiating power from the center toward the limb of the solar disk". 668.

— H. B. A. BOCKWINKEL: "On the propagation of light in a biaxial crystal around a centre of vibration". 728.

— J. E. VERSCHAFFELT: "Contributions to the knowledge of VAN DER WAALS' $\psi$-surface. X. On the possibility of predicting the properties of mixtures from those of the components." 743.

— J. E. VERSCHAFFELT: "Appendix to the communications published in the meetings of June 28, September 27, 1902 and October 31, 1903". 752.

— F. M. JAEGER: "A simple geometrical deduction of the relations between known and unknown quantities, mentioned in the method of VOIGT for determining the conductibility of heat in crystals". 793.

— P. ZEEMAN: "Magnetic resolution of spectral lines and magnetic force". 1st part. 814.

**Physiology.** H. ZWAARDEMAKER: "On the pressure of sound in Corti's organ". 60.

— W. EINTHOVEN: "Analysis of the curves obtained with the string galvanometer. Mass and tension of the quartz wire and resistance in the motion of the string". 210.

— G. VAN RYNBERK: "The designs on the skin of the vertebrates, considered in their connection with the theory of segmentation". 307.

— C. A. PEKELHARING: "On the excretion of creatinin in man". 363.

— H. J. HAMBURGER: "A method for determining the osmotic pressure of very small quantities of liquid". 394.

— H. ZWAARDEMAKER: "On the ability of distinguishing intensities of tones". 421.

— L VAN ITALLIE: "On catalases of the blood". 623.

— L. VAN ITALLIE: "On the differentiation of fluids of the body, containing proteid". 628.

**Physiology**. H. ZWAARDEMAKER: "On the strength of the reflex-stimuli as weak as possible". 821.

PLAITPOINT CURVE (On the phenomena which occur when the) meets the three phase line of a dissociating binary compound. 571.

PLAITPOINT CURVES (On the shape of the) for mixtures of normal substances. 2nd communication. 33.

PLAITPOINT LINE (Properties of the critical line) on the side of the components. 271.

— (The exact numerical values for the properties of the) on the side of the components. 289.

PLAITPOINT LINES (On the course of the spinodal and the) for binary mixtures of normal substances. 3rd communication. 578.

PLANT (Thalictrum aquilegifolium, a hydrogen cyanide-yielding). 337.

PLANTS (An enumeration of the vascular) known from Surinam, together with their distribution and synonymy. 639.

— (On) which in the natural state have the character of eversporting varieties in the sense of the mutation theory. 798.

PLÜCKER equivalents (The) of a cyclic point of a twisted curve. 498.

POL (D. J. HULSHOFF). v. HULSHOFF POL (D. J.)

POLYANDRY of Scalpellum Stearnsi (On the). 659.

POSTMA (O.). Some remarks on the quantity $H$ in Boltzmann's "Vorlesungen über Gastheorie." 630.

PRESSURE (Improvement to the open mercury manometer of reduced height with transference of) by means of compressed gas. 75.

— (Improvement in the transference of) by compressed gas especially for the determination of isothermals. 76.

— (The Tx-equilibria of solid and fluid phases for variable values of the). 193.

— of sound (On the) in Corti's organ. 60.

PRIMATES (On the relation between the teeth-formulas of the platyrrhine and catarrhine). 781.

PRISMATIC CAMERA (The). 505.

PROBABILITY PROBLEM (A local). 341.

PROTEID (On the differentiation of fluids of the body, containing). 628.

PULLE (A. A.). An enumeration of the vascular plants known from Surinam, together with their distribution and synonymy. 639.

QUADRATIC SURFACES (A particular series of) with eight common points and eight common tangential planes. 754.

QUANTITY $H$ (Some remarks on the) in BOLTZMANN's "Vorlesungen über Gastheorie." 630.

QUARTZ WIRE (Mass and tension of the) and resistance to the motion of the string. 210.

RADIATING POWER (A new method for determining the rate of decrease of the) from the center toward the limb of the solar disk. 668.

RADIATION (Measurement of the heat produced by the integral) of the corona and the solar disk. 503.

— of heat (On the) in a system of bodies having a uniform temperature. 401.

RATE OF DECREASE (A new method for determining the) of the radiating power from the center toward the limb of the solar disk. 668.

RATIO of the triangles (Approximate formulae of a high degree of accuracy for the) in the determination of an elliptic orbit from three observations. II. 104.

RAYS (A group of complexes of) whose singular surface consists of a scroll and a number of planes. 662.

REFLECTION (Derivation of the fundamental equations of metallic) from CAUCHY's theory. 486.

— of light (On the theory of) by imperfectly transparent bodies. 377.

REFLEX-STIMULI (On the strength of the) as weak as possible. 821.

ROCKS (On fragments of) from the Ardennes found in the diluvium of the Netherlands North of the Rhine. 518.

ROMBURGH (P. VAN) presents a paper of Dr. F. M. JAEGER: "On some derivatives of Phenylcarbamic acid." 127.

— On the presence of lupeol in some kinds of gutta-percha. 137.

— On the action of ammonia and amines on allyl formate. 138.

— presents a paper of Dr. A. J. ULTEE: "On the action of hydrocyanic acid on ketones". 141.

— presents a paper of Dr. L. VAN ITALLIE: "Thalictrum aquilegifolium, a hydrogen cyanide-yielding plant". 337.

— On the action of ammonia and amines on formic esters of glycols and glycerol. 339.

— presents a paper of Dr. C. J. ENKLAAR: "On Ocimene and Myrcene, a contribution to the knowledge of the aliphatic terpenes." 714.

— presents a paper of Dr. C. J. ENKLAAR: "On some aliphatic terpene alcohols." 723.

— and N. H. COHEN: "The occurrence of $\beta$-amyrine acetate in some varieties of gutta percha". 544.

— and W. VAN DORSSEN: "The reduction of acraldehyde and some derivatives of s. divinylglycol (3.4 dihydroxy 1.5 hexadiene). 541.

— On the simplest hydrocarbon with two conjugated systems of double bonds, 1.3.5 hexatriene. 565.

ROOZEBOOM (H. W. BAKHUIS). v. BAKHUIS ROOZEBOOM (H. W.).

RIJNBERK (G. VAN). The designs on the skin of the vertebrates, considered in their connection with the theory of segmentation. 307.

SANDE BAKHUYZEN (H. G. VAN DE) presents a paper of J. WEEDER: "Approximate formulae of a high degree of accuracy for the ratio of the triangles in the determination of an elliptic orbit from three observations". II. 104.

— Preliminary Report on the Dutch expedition to Burgos for the observation of the total solar eclipse of August 30, 1905. 501.

— presents a paper of Dr. H. J. ZWIERS: "Researches on the orbit of the periodic comet Holmes and on the perturbations of its elliptic motion". 642.

SATELLITES (On the orbital planes of Jupiter's). 767.

SCALPELLUM STEARNSI (On the polyandry of). 659.

SCHOUTE (C.). Determination of the Thomson-effect in mercury. 331.

SCHOUTE (P. H.) presents a communication Dr. W. A. VERSLUYS: "On the rank of the section of two algebraic surfaces". 52.

SCHOUTE (P. H.). A tortuous surface of order six and of genus zero in space $Sp_4$ of four dimensions. 489.

— presents a paper of Dr. W. A. VERSLUYS: "The PLÜCKER equivalents of a cyclic point of a twisted curve." 498.

— A particular series of quadratic surfaces with eight common points and eight common tangential planes. 754.

SECTION of two algebraic surfaces (On the rank of the). 52.

SECTIONS (On the hidden equilibria in the $p,x$-) below the eutectic point. 568.

SEGMENTATION (The designs on the skin of the vertebrates, considered in their connection with the theory of). 307.

SILAT in Western-Borneo (On brackish and fresh water deposits of the river). 742.

SISSINGH (R.). On the theory of reflection of light by imperfectly transparent bodies. 377.

— Derivation of fundamental equations of metallic reflection from CAUCHY's theory. 486.

SITTER (W. DE). On the orbital planes of Jupiter's satellites. 767.

SKIN (The designs on the) of the vertebrates, considered in their connection with the theory of segmentation. 307.

SMITS (A.). On the hidden equilibria in the $p,x$-diagram of a binary system in consequence of the appearance of solid substances. 196.

— Contribution to the knowledge of the $px$- and the $pT$-lines for the case that two substances enter into a combination which is dissociated in the liquid and the gasphase. 200.

— On the hidden equilibria in the $p,x$-sections below the eutectic point. 568.

— On the phenomena which occur when the plaitpoint curve meets the three phase line of a dissociating binary compound. 571.

SÖHNGEN (N. L.). Methan as carbon-food and source of energy for bacteria. 327.

SOLAR ACTIVITY (Oscillations of the) and the climate. 2nd communication. 155.

SOLAR DISK (Measurement of the heat produced by the integral radiation of the corona and of the). 503.

— (A new method for determining the rate of decrease of the radiating power from the center toward the limb of the). 668.

SOLAR ECLIPSE (Preliminary Report on the Dutch expedition to Burgos for the observation of the) of August 30, 1905. 501.

— (Report on the operations with the two slit-spectrographs for the) of August 30, 1905. 506.

SOLUBILITIES (The) of the isomeric chromic chlorides. 66.

SOLUTIONS (The boiling points of saturated) in binary systems in which a compound occurs. 536.

SOUND (On the pressure of) in Corti's organ. 60.

SPACE $Sp_4$ (A tortuous surface of order six and of genus zero in) of four dimensions. 489.

— of LOBATSCHEFSKY (Central projection in the). 1st part. 389.

SPECTRAL LINES (Magnetic resolution of) and magnetic force. 1st part. 814.

SPECTROGRAPHS (Report on the operations with the two slit-) for the solar eclipse of August 30, 1905. 506.

SPICULES of sponges (On the structure of some siliceous). I. The styli of Tethya lyncurium. 15.

SPINODAL and the plaitpoint lines (On the course of the) for binary mixtures of normal substances. 3rd communication. 578.

SPONGES (On the structure of some siliceous spicules of). I. The styli of Tethya lyncurium. 15.

ST. DENIS (Island of Réunion) (Supplement to the account of the determination of the longitude of), executed in 1874, containing also a general account of the observation of the transit of Venus. 110.

STEMS and flower-stalks (Some observations on the longitudinal growth of). 8.

STILBENE and Dibenzyl (On Diphenylhydrazine, Hydrazobenzene and Benzylaniline, and on the miscibility of the last two with Azobenzene) in the solid aggregate condition. 466.

STOK (J. P. VAN DER). On frequency curves of meteorological elements. 314.

— On frequency curves of barometric heights. 549.

STRAHL (H.). The uterus of Erinaceus europaeus L. after parturition. 812.

STRING (Mass and tension of the quartz wire and resistance to the motion of the). 210.

SUBSTANCES (On the hidden equilibria in the $p,x$-diagram of a binary system in consequence of the appearence of solid). 196.

— (Contribution to the knowledge of the $p,x$-and the $p,T$- lines for the case that two) enter into a combination which is dissociated in the liquid and the gasphase. 200.

SURFACE (A tortuous) of order six and of genus zero in space $Sp_4$ of four dimensions. 498.

$\psi$-SURFACE (Contributions to the knowledge of VAN DER WAALS'). X. On the possibility of predicting the properties of mixtures from those of the components. 743.

SURFACE OF SATURATION (The shape of the sections of the) normal to the $x$-axis, in case of a three phase pressure between two temperatures. 184.

SURFACE OF SATURATION (The properties of the sections of the) of a binary mixture on the side of the components. 280.

SURFACES (A particular series of quadratic) with eight common points and eight common tangential planes. 754.

SURINAM (An enumeration of the vascular plants known from) together with their distribution and synonymy. 639.

TANGENTS (On the number of common) of a curve and a surface. 176.

TARSIUS SPECTRUM (On the primordial cranium of). 397.

TEETH-FORMULAS (On the relation between the) of the platyrrhine and catarrhine primates. 781.

TEMPERATURE (The molecular rise of the lower critical) of a binary mixture of normal components. 144.

— (On the radiation of heat in a system of bodies having a uniform). 401.

TEMPERATURES (The shape of the sections of the surface of saturation normal to the $x$-axis, in case of a three phase pressure between two). 184.

— below —210° C. (Cryostat with liquid oxygen for). 79.

TERPENE ALCOHOLS (On some aliphatic). 723.

TERPENES (On Ocimene and Myrcene, a contribution to the knowledge of the aliphatic). 714.

TETHYA LYNCURIUM (The styli of). 15.

TETRAHEDRAL COMPLEX (An article on the knowledge of the). 358.

THALICTRUM AQUILEGIFOLIUM, a hydrogen cyanide-yielding plant. 337.

THEORY of reflection of light (On the) by imperfectly transparent bodies. 377.

THOMSON-EFFECT (Determination of the) in mercury. 331.

TIMOR (On a new species of Corallium from). 268.

TOLUENE (The bromination of). 512.

TONES (On the ability of distinguishing intensities of). 421.

TRANSIT of Venus (Supplement to the account of the determination of the longitude of St. Denis (Island of Réunion), executed in 1874, containing also a general account of the observation of the). 110.

TRIANGLES (Approximate formulae of a high degree of accuracy for the ratio of the) in the determination of an elliptic orbit from three observations. II. 104.

TRIBROMOXYLENES (On the six isomeric). 153.

ULTEE (A. J.). On the action of hydrocyanic acid on ketones. 141.

UTERUS (The) of Erinaceus europaeus L. after parturition. 812.

VENUS (Supplement to the account of the determination of the longitude of St. Denis (Island of Réunion), executed in 1874, containing also a general account of the observation of the transit of). 110.

VERSCHAFFELT (E.). Some observations on the longitudinal growth of stems and flower-stalks. 8.

VERSCHAFFELT (J. E). Contributions to the knowledge of VAN DER WAALS' $\psi$-surface. X. On the possibility of predicting the properties of mixtures from those of the components. 743.

— Appendix to the communications published in the meetings of June 28, September 27, 1902 and October 31, 1903. 752.

VERSLUYS (W. A.). On the rank of the section of two algebraic surfaces. 52.

— On the number of common tangents of a curve and a surface. 176.

— The PLÜCKER equivalents of a cyclic point of a twisted curve. 498.

VERTEBRATES (The designs on the skin of the), considered in their connection with the theory of segmentation. 307.

VIBRATION (On the propagation of light in a biaxial crystal around a centre of). 728.

VOIGT (A simple geometrical deduction of the relations existing between known and unknown quantities, mentioned in the method of) for determining the conductibility of heat in crystals. 793.

VOSMAER (G. C. J.) and H. P. WIJSMAN. On the structure of some siliceous spicules of sponges. I. The styli of Tethya lyncurium. 15.

VRIES (H. DE). Central projection in the space of LOBATSCHEFSKY. 1st part. 389.

VRIES (HUGO DE) presents a communication of Prof. E. VERSCHAFFELT: "Some observations on the longitudinal growth of stems and flower-stalks". 8.

VRIES (JAN DE). On pencils of algebraic surfaces. 29.

VRIES (JAN DE) presents a paper of Z. P. BOUMAN: "An article on the knowledge of the tetrahedral complex." 358.

— A group of complexes of rays whose singular surface consists of a scroll and a number of planes. 662.

— Some properties of pencils of algebraic curves. 817.

WAALS (VAN DER) $\psi$-surface (Contributions to the knowledge of). X. On the possibility of predicting the properties of mixtures from those of the components. 743.

WAALS (J. D. VAN DER). The shape of the sections of the surface of saturation normal to the $x$ axis, in case of a three phase pressure between two temperatures. 184.

— The $T,x$-equilibria of solid and fluid phases for variable values of the pressure. 193.

— presents a paper of Dr. A. SMITS: "On the hidden equilibria in the $p,x$-diagram of a binary system in consequence of the appearance of solid substances." 196.

— presents a paper of Dr. A. SMITS: "Contribution to the knowledge of the $px$- and the $pT$-lines for the case that two substances enter into a combination which is dissociated in the liquid and the gasphase." 200.

— Properties of the critical line (plaitpoint line) on the side of the components. 271.

— The properties of the sections of the surface of saturation of a binary mixture on the side of the components. 280.

— The exact numerical values for the properties of the plaitpoint line on the side of the components. 289.

— presents a paper of Prof. J. D. VAN DER WAALS JR.: "Remarks concerning the dynamics of the electron." 477.

WAALS JR. (J. D VAN DER). Remarks concerning the dynamics of the electron. 477.

WEBER (MAX) presents a paper of Prof. SYDNEY J. HICKSON: "On a new species of Corallium from Timor." 268.

WEEDER (J.). Approximate formulae of a high degree of accuracy for the ratio of the triangles in the determination of an elliptic orbit from three observations. II. 104.

WENT (F. A. F. C.). Some remarks on the work of Mr. A. A. PULLE, entitled: "An enumeration of the vascular plants known from Surinam, together with their distribution and synonymy." 639.

— and A. H. BLAAUW. On a case of apogamy observed with Dasylirion acrotrichum Zucc. 684.

WICHMANN (C. E. A.). On fragments of rocks from the Ardennes found in the diluvium of the Netherlands North of the Rhine. 518.

WILTERDINK (J. H.). Report on the operations with the two slit-spectrographs for the solar eclipse of August 30, 1905. 506.

WIND (C. H.) presents a paper of C. EASTON: "Oscillations of the solar activity and the climate". 2nd communication. 155.

WINKLER (C.) presents a paper of D. J. HULSHOFF POL: "BOLK's centra in the cerebellum of the mammalia". 298.

— presents a paper of Dr. G. VAN RIJNBERK: "The designs on the skin of the vertebrates, considered in their connection with the theory of segmentation". 307.

— presents a paper of Dr. L. J. J. MUSKENS: "Anatomical research about cerebellar connections." 563.

WIJSMAN (H. P.) and G. C. J. VOSMAER. On the structure of some siliceous spicules of sponges. I. The styli of Tethya lyncurium. 15.

ZEEMAN (P.) presents a paper of Dr. F. M. JAEGER: "A simple geometrical deduction of the relations existing between known and unknown quantities, mentioned in the method of VOIGT for determining the conductibility of heat in crystals." 793.

— Magnetic resolution of spectral lines and magnetic force. 1st part. 814.

**Zoology.** G. C. J. VOSMAER and H. P. WIJSMAN: "On the structure of some siliceous spicules of sponges. I. The styli of Tethya lyncurium." 15.

— SYDNEY J. HICKSON: "On a new species of Corallium from Timor." 268.

— EUGEN FISCHER: "On the primordial cranium of Tarsius spectrum." 397.

— P. P. C. HOEK: "On the polyandry of Scalpellum Stearnsi." 659.

— H. STRAHL: "The uterus of Erinaceus europaeus L. after parturition." 812.

ZWAARDEMAKER (H.). On the pressure of sound in Corti's organ. 60.

— On the ability of distinguishing intensities of tones. 421.

— On the strength of the reflex-stimuli as weak as possible. 821.

ZWIERS (H. J.). Researches on the orbit of the periodic comet HOLMES and on the perturbations of its elliptic motion. 642.